THE GENERALIZABILITY OF PRIVATE SECTOR RESEARCH ON SOFTWARE PROJECT MANAGEMENT IN TWO USAF ORGANIZATIONS: AN EXPLORATORY STUDY

THESIS

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Michael R. Garman

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Abstract

Project managers typically set three success criteria for their projects: meet specifications, be on time, and be on budget. However, software projects frequently fail to meet these criteria.

Software engineers, acquisition officers, and project managers have all studied this issue and made recommendations for achieving success. But most of this research in peer reviewed journals has focused on the private sector. Researchers have also identified software acquisitions as one of the major differences between the private sector and public sector MIS. This indicates that the elements for a successful software project in the public sector may be different from the private sector.

Private sector project success depends on many elements. Three of them are user interaction with the project's development, critical success factors, and how the project manager prioritizes the traditional success criteria. High user interaction causes high customer satisfaction, even when the traditional success criteria are not completely met. Critical success factors are those factors a project manager must properly handle to avoid failure. And priorities influence which success criteria the project manager will most likely succeed in meeting.

Through a survey of software project managers at two USAF software development organizations, my research discovered the following:

1) Air Force software project managers' top priority is fulfilling requirements,
2) User interaction during the software life cycle strongly influences user satisfaction with the final product, and
3) Air Force and private sector projects share many of the same critical success factors for nonweapon systems, but there are still some sharp differences.

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I. Introduction

Background

Professional project management deals with multi-million dollar endeavors that can take years to finish. Space programs, buildings, bridges, dams, pharmaceutical products, jets, and weapon systems are all traditional examples of programs that require project management. During the last three decades, software projects have joined this group and challenged project managers with their intangible existence and complexity.

The proper management of software projects makes the difference in achieving the three traditional success criteria: completing the project on budget, implementing the project on schedule, and fulfilling all of the users' specifications. Nonetheless, project success is a difficult outcome to nail down. The user of this software product must be satisfied with the software product and use it before recognizing it as a success, regardless of how well the project manager achieves other criteria. The user's attitude, involvement, and participation with the project's development greatly influence satisfaction. Likewise, additional success factors are critical in reaching the traditional success criteria (such as support from senior management, effective management of risk, and effective leadership).

Due to difficulties in attaining these criteria, literature has noted many projects that have failed some or all of these criteria. For example, the Standish Group Report (1995) discussed their research for 365 companies on 8,380 software projects. 31% of the projects were cancelled.

53% of the completed projects were 189% over budget. And only 16% of the completed projects actually finished on time and on budget.

Meanwhile, the Department of Defense is acquiring and maintaining weapon systems that depend on these software projects to be successful (Table 1). For example, the defunct Crusader Artillery used 1,800,000 lines of code, and the nearly complete F-22 uses 1,960,000 lines of code. The success of these software systems impact the survival of Americans and mission accomplishment. Likewise, successful nonweapon software systems increase the military's productivity and communications capabilities. For example, the USAF plans to connect 700 software systems with the Air Force Portal so members have access to all the information they require for their duties.

Table 1

Weapon System Software Sizes

Weapon System	Source Lines of Code
M1 Tank	600,000
Scout / Cav	1,000,000
M2 Infantry Fighting Vehicle	1,560,000
Crusader Artillery	1,800,000
F-22	1,960,000
Aegis	2,840,000

Note. From "Curing the Software Requirements and Cost Estimating Blues," by M. Nelson, J. Clark, and M. A. Spurlock, 1999, *Program Manager*, 17, p. 54.

Problem Statement

In response to these stories of software crises and project failures, many professional journals (such as Cross Talk for DoD software engineers) and peer-reviewed literature have published articles on software projects and project management in general. However, there is little published research that focuses specifically on software projects within the military and federal government; practically all literature deals with software projects in the private sector. Military project management for software development and maintenance is a highly relevant

issue because the military has had an equally difficult time with it as the private sector. For example, the Air Force spent $60 million and 5 years on developing a new personnel information software system. In May of 2001, the Air Force launched this new system and immediately started having problems, such as preventing new military members from receiving pay. A year later, the software system still suffered glitches. At the Air Force Personnel Center's website http://www.afpc.randolph.af.mil/modern/, technicians reported correcting 4,944 problems with the personnel system as of August 19th, 2002. But on the same day, they also reported 461 more complaints and bugs to pursue. By 2004, the U.S. Army plans to begin designing an even larger software system modeled off of the Air Force system at an expense of $500 million.

Our military aircraft are also increasingly becoming dependent on software. As Table 2 shows, in 1960, only 8% of the F-4's functions depended on software. But within 10 years, 20% of the F-111's functions depended on software, and, in 1990, the B-2's functions were software dependent by 65%.

Table 2

Weapon System Software Dependencies

Weapon System	Year	Percent of Functions Performed in Software
F-4	1960	8
A-7	1964	10
F-111	1970	20
F-15	1975	35
F-16	1982	45
B-2	1990	65
F-22	2000	80

Note. From "Curing the Software Requirements and Cost Estimating Blues," by M. Nelson, J. Clark, and M. A. Spurlock, 1999, *Program Manager*, 17, p. 55.

These weapon systems and software systems are just several of many software products that the Air Force depends on for mission accomplishment. Consequently, research on the generalizability of private sector research to the public sector can help confirm Air Force current practices or identify the necessity for different methodologies for software project management in the military.

Research Question and Investigative Questions

Because the Air Force is subject to the same software project management problems as the private sector, the Air Force would benefit from research generalizable to the military for its current and future software project management endeavors. However, after conducting an exhaustive review of the literature, I was unable to find any substantive research on this subject regarding military software project management. Therefore, I conducted an exploratory study to learn about military software project management and break new ground in this field. My overall research question asked, "How do the success factors in software project management for the Air Force differ (if at all) from the private sector?"

This question covered a very diverse topic, considering all the possible factors that can go into successful project management. Therefore, the only factors studied were those under the project manager's control (i.e.: no environmental factors, which are outside of the project manager's control). Three investigative questions narrowed the scope of this thesis:

1. How do Air Force software project managers prioritize the three traditional measures of project success?
2. Does high user interaction in Air Force software projects correlate with project success?
3. Are the critical success factors for Air Force software projects different from private sector projects?

These investigative questions required a variety of data to answer them. Software project managers from two Air Force units, "Organization Alpha" and "Organization Bravo," responded to a questionnaire to provide data for the investigative questions. Both Organizations Alpha and Bravo develop and sustain software for the Air Force, either by developing in-house, adapting commercial off the shelf products, or supervising contracted out work. For the first question, project managers prioritized success criteria under different situations, which showed how

project managers most frequently prioritize their goals. For the second question, project managers used a validated questionnaire to score user involvement in projects and their project's level of success. And for the third question, project managers used a survey to list all the factors that are critical to project success. This data was then analyzed through comparison with private sector research and statistical methods.

Terminology

This research focused on software, as defined by the Software Engineering Process List of Definitions (Anon, 2002) and derived from Peach (1992): "Intellectual creation comprising the programs, procedures, rules and any associated documentation pertaining to the operation of a data processing system. Computer programs and computer databases." All information systems referred to in the literature review are under the context of being software systems, such as computer databases, rather than non-software systems, such as a library card catalog. Articles referring to project management in general are noted as general projects, rather than as specifically software projects. This research does not include information technology, which involves both software and hardware.

The distinction between "users" and "customers" is also important to this thesis. According to the Software Engineering Process List of Definitions (Anon, 2002), a "user" (a.k.a. end-user) is "the individual or group who will use the system for its intended operational use when it is deployed in its environment." A "customer" is "the individual or organization that is responsible for accepting the product and authorizing payment to the developing organization."

Both surveyed Air Force organizations maintained identical software terminology and agreed upon definitions on their websites. Furthermore, this research excluded software on weapon systems. Military software projects resembling private sector software projects were

used for the most accurate comparison. Both surveyed Air Force organizations developed and maintained such software, and examples in the questionnaire also resembled software applications and information systems that a private sector company would develop.

Thesis Overview

This thesis is divided into five chapters. Chapter I discusses the background and the problem of software project success and how this issue relates to the military. Investigative questions narrow down the scope to project success influenced by goals, user interaction, and critical success factors. Chapter II reviews peer-reviewed literature on these constructs. Chapter III describes the development of the questionnaire and the statistical methods used to analyze the data. Chapter IV presents the data and its analysis for each investigative question and any conspicuous differences between cross sections of the data. And Chapter V interprets the data analysis in answer to the investigative questions and recommends future research.

II. Literature Review

Overview

Researchers and subject matter experts have identified differences in methodology between public and private software acquisitions. However, this study was unable to find any research specifically on differences between private and public sector project management. Literature indicates how various factors influence the perceived success of projects (Table 1).

Table 3
Definitions of Constructs

Construct	Definition
Communication	The provision of an appropriate network and necessary data to all key actors in the project implementation, including the user and customer (Slevin & Pinto, 1986).
Critical Success Factors	The few factors that will ensure success in a particular business area if the manager gives them the necessary attention. Likewise, if these factors are disregarded, the endeavor is bound to fail (Rockart, 1979).
Customer Satisfaction	The product satisfies all needs and expectations and the user is pleased with it, despite whether it is on time, on budget, and fulfills all specifications (Pinto & Slevin, 1988).
Project Success	Consists of both user satisfaction and the traditional success criteria (Pinto & Slevin, 1988).
Traditional Success Criteria	The project must deliver a product on schedule, on budget, and according to performance specifications (Pinto & Slevin, 1988).
User Consultation	Communication, consultation, and active listening to all impacted parties (Slevin & Pinto, 1986).
User Acceptance	The act of "selling" the final project to its ultimate intended users (Slevin & Pinto, 1986).
User Interaction	Having a user (or a liaison) participate in project activities, feel involved with the progress of the project and its upcoming usefulness, and develop a confident attitude that the project is being managed well despite any adverse conditions (Barki & Hartwick, 1989).

Differences Between Private Sector and Public Sector MIS

Previous research suggests substantive differences between public and private sector management information systems (Bozeman & Bretschneider, 1986; Bretschneider, 1990; Caudle, Gore, & Newcomer, 1991). Management information systems (MIS) "concerns both the management of information technology and the use of information technology for managerial and organizational purposes" (Ives, 1995). In regard to software project management and related acquisitions, Bozeman and Bretschneider (1986) note public sector MIS "requires a protracted period of testing and prototype development." Strong accountability is necessary because government software projects are open to public scrutiny. And Bretschneider (1990) adds that private sector organizations evaluate software acquisitions by the economic efficiency of their performance. However, public sector software acquisitions are strongly influenced by procedural equity such as acquisition regulations, government contracting rules, and Department of Defense (DoD) standards. In a review of DoD software acquisitions, Jones (2002a), a subject matter expert, anecdotally notes even more differences in the public sector. In addition to a highly regulated contractual procurement process, he also observes that military procurement frequently has litigation challenging the successful bidder (with side-effects like delays in the project schedule) and extensive oversight and control requirements (resulting in documentation three times larger than equivalent civilian projects).

On the other hand, Devlin and Royce (1994) comment in an Air Force software acquisition book that "many commercial practices are inappropriate to most DoD software (the glaring exception is DoD's MIS systems which only differ by perhaps their scale)."

These differences in MIS and software acquisition procedures and rules begs the question whether public sector project management of software is distinctly different from the private sector. If it is, then military software project management may require a different form of

methodology from what the private sector uses. This research sought to study common constructs in project management within two Air Force software developing organizations that might question or affirm the generalizability of private sector research on those two Air Force organizations.

Project Management Constructs Under Review

While many factors contribute to a project's successful completion, only some of these factors are under the project manager's control. This research studied those non-environmental factors that are most critical to project success. These factors influence the achievement of customer satisfaction and completing software projects on time, on budget, and within specifications. The literature review covers the following constructs toward achieving project success: critical success factors (CSFs), user interaction and customer satisfaction, and success criteria and priorities.

Critical Success Factors Research

J. F. Rockart (1979) defines critical success factors (CSFs) as the few factors that will ensure success in a particular business area if the manager gives them the necessary attention. Likewise, if these factors are disregarded, the endeavor is bound to fail. Boynton and Zmud (1984) researched the CSF construct through case studies and concluded that it is a valid construct worthy of further research. Their research indicates that two CSFs are managerial support and "a positive relation and a meaningful dialogue with users." Various researchers have since studied CSFs for project management (Delano 1998; Dobbins 1998; Pinto & Slevin 1987; White & Fortune 2002). Each researcher has concluded with slightly different factors, but all of them have found the user of the project to be a factor of success.

Dobbins (1998) notes the scarcity of articles on military project management and then details critical success factors for defense acquisition programs. He surveyed two groups of defense program managers: those who worked on software for weapon systems and those who worked on software for information systems. Delano (1998) made a similar survey for the CSFs of defense acquisitions (but not specifically software). Both studies indicate a strong user relationship was one of the top six factors. Jones (2002b), a subject matter expert, observed twelve CSFs while judging 16 of the best DoD software projects for 2001. Beyond these two, the majority of project management articles in peer-reviewed journals deal with the private sector.

Pinto and Slevin (1987) initially constructed their list of 10 CSFs from a card-based survey of MBA students on important factors for successful projects of all types. Since then, they have repeatedly tested and verified their CSFs in subsequent studies (Pinto & Mantel, 1990; Pinto & Slevin, 1988). Their studies indicate three factors that particularly influence obtaining customer satisfaction: (a) client consultation (actively listening to the client and discussing realistic expectations), (b) client acceptance (convincing the client the project is worth the expense and trouble of difficulties), and (c) communication (updating the client, providing feedback, asking for input). Slevin and Pinto (1986) designed a survey to measure how well a project manager handled the 10 CSFs on a current project. Subsequently, Pinto and Slevin (1988) tested an addition to the questionnaire to evaluate the success of a project from the project manager's perceptions. Success was partly based off of the elicitation of a positive user attitude toward the final product.

White and Fortune's study (2002) is one of the most recent studies on CSFs. They surveyed project managers from 88 different industries, but only 5 worked in defense. Of the

236 respondents, 60 managed an "information technology" project, 26 had a "software development" project, and 7 had dealt with a software project on "Year 2000 compliance." White and Fortune's questionnaire offered a list of 19 CSFs taken from literature (including Pinto and Slevin, 1987). They expanded the list to 23 when some of the respondents offered additional CSFs that literature had not yielded. Their results indicate user commitment to the project is among the top five CSFs.

Importance of User Interaction to User Satisfaction

Various literature discusses the importance of having user interaction throughout the project life cycle to ensure user satisfaction and acceptance of the product, even when other success criteria (such as the schedule) are broken.

Deutsch (1991) expanded the traditional success criteria (requirements, schedule, and budget) for software products to include user satisfaction, which is how much users are satisfied with the system's performance. This is distinct from meeting specifications, which may not always fulfill the true expectations of the user.

Wateridge (1999) also notes the users and project manager must meet periodically as ideas for the project solidify and become detailed. User participation is necessary for customer satisfaction.

Barki and Hartwick (1989) broke user interaction down into three phrases: of user attitude, user involvement, and user participation. Up to that point, researchers used the words interchangeably. But Barki and Hartwick noted the fields of psychology, marketing, and organizational behavior referred to "involvement" as an intrinsically important and personal event. Whereas MIS researchers used "involvement" just like "participation," in which a person is doing a set of activities with other people. "User attitude" describes how positively a person

evaluates a new software information system or how that person feels about it. Barki and Hartwick argue these three constructs should be made consistent among other fields of study and be recognized as distinct constructs.

To test these constructs, Barki and Hartwick (1994) designed a questionnaire to measure user participation, attitude, and involvement. They gathered 59 questions from previous research, conducted a survey, and then rigorously tested it for reliability and validity to make sure the questionnaire consistently evaluated the content they had in mind.

Barki and Hartwick (1994) note there is a moderate correlation between user participation and user attitude and user involvement. When a user participates in a software project, the user takes a personal interest in the project's success, feels ownership for it, and judges the project is more likely to succeed.

Hunton and Beeler (1997) took Barki and Hartwick's research (1994) another step by conducting an experiment to test this correlation. Their results indicate users are happier with a software system when they are involved with its development. When the user feels he has influence over the input, then he likes the output. Hunton and Beeler's results suggest that software project managers should encourage user interaction, especially when the user can make an impact.

Success Criteria and Priorities

Barki, Rivard, and Talbot (2001) conducted an experiment to test how the user influences the project's success. They define success by measuring process performance (on time, on budget) and product performance (meets specifications and quality expectations). They found that project managers were more successful depending on how they prioritized to reach their goals. Project managers were more successful in reaching the goal of meeting process

performance by focusing on the schedule and budget. But when the project manager's primary goal was system quality, then he was more successful by eliciting user participation.

Atkinson (1999) argues that researchers should review the traditional success criteria of projects, namely, (a) being on time, (b) on budget, and (c) meeting product specifications. He said these three make up the Iron Triangle and that projects seem to frequently fail because these criteria for success are inadequate; they do not properly describe standards for judging a successful project. Success criteria should adapt to the priorities of each project. For example, life critical systems (such as military fighter jet software) should have quality as the overriding criteria. Time and cost are secondary issues in this case.

Lim and Mohamed's inductive study (1999) notes that while project managers measure success off of the traditional success criteria, customers measure it according to their perceptions and satisfaction with the project. Lim and Mohamed theorize that true project success depends on fulfilling all of these criteria, with an emphasis on the customer's perceptions. A project manager considers a project a failure when it goes over time and over budget while properly meeting specifications. But the customer is happy over the long term because the time and budget issues are only temporary stumbling blocks in getting what he wanted. For example, the project managers for the new F-22 judge their success based off of the Iron Triangle. But 10 years from now, an F-22 pilot will not care whether the project went over time and over budget. All the pilot cares about is whether the plane fulfills all his expectations and makes him a satisfied customer. Wateridge's research (1995, 1998) indicates similar conclusions; when the project manager secures customer satisfaction, an over budget and overtime project is still a success.

Dobbins (1998) notes that even though customer satisfaction engenders project success, program managers most often measure projects by cost and schedule because they must brief oversight agencies. This puts a project manager into conflict when customer satisfaction and meeting specifications requires going over budget and over time. Fulfilling all these goals becomes a difficult issue because the project manager must prioritize.

Milosevic, Inman, and Ozbay's research (2001) indicates that organizations using strategic project management have successfully focused on one of the three traditional success criteria and derived appropriate results (i.e., schedule-driven groups were always on schedule, but quality and budget could suffer).

Abdel-Hamid, Sengupta, and Swett (1999) studied this issue at the project manager level for software projects. When a project manager's goal is to finish a software project on time and on budget, his behavior follows through. Likewise, when a project manager's goal is to be on time and provide a quality product, his behavior follows through for timing and higher quality.

Fowler's research (1999) notes that project managers cause their projects to go over budget by forcing the project to either meet an unrealistic schedule or crashing the time to eliminate slack and finish early. Ironically, though, his research also indicates that the quality of the product lowers because the project manager cut corners and the customer perceives the project to be low quality work. Fowler concludes that project success depends on customer satisfaction, not solely meeting two of the three standard success criteria. Khang and Myint's study (1999) made similar conclusions; crashing time causes the project to go over budget and may still not satisfy the customer.

Delano (1998) surveyed program managers on their success criteria and discovered that the highest ranking success indicator was meeting technical performance objectives, and the second to last was meeting cost objectives.

Rush (1997) notes that, prior to 1995, requirements and sometimes schedules determined costs in defense acquisitions. These acquisitions were made in an environment with a more plentiful defense budget. But in 1995, decision makers formulated Cost as an Independent Variable (CAIV) in reaction to a decreasing defense budget. CAIV requires personnel to control requirements and schedules with as cost as the top priority. CAIV was first implemented in 1996, and it continues to be emphasized in the latest guidance (DoD, 2002).

Therefore, while private sector research indicates project managers prioritize requirements as their top priority, defense regulations have required cost as the top priority for the last eight years (DoD, 2002). Nonetheless, defense software projects are still not finishing on budget (Nelson, Clark, & Spurlock, 1999).

Summary

The literature in general project management and software project management shows many factors go into producing a successful project. Critical success factors demand the attention of the project manager while administering the project through its life cycle. Another issue is the priority the project manager gives each of the traditional success criteria and customer satisfaction. Even the definition of project success becomes a matter of importance: to have a truly satisfied customer, the project manager must go beyond considering just the schedule, budget, and requirements. Having the user interact with the project's development can go a long ways toward securing that satisfaction. But little research has been done on Air Force software project management and its possible differences from the private sector. If these differences are great, then private sector research on project success is not easily generalizable to

the Air Force. Consequently, this study sought to explore this issue by surveying Air Force software project managers on their project goals, user interaction and project success, and the factors they consider critical for success.

III. Methodology

Overview

Software project managers responded to an online questionnaire consisting of three parts: ipsative questions on success criteria priorities, Likert scale questions on user involvement and success, and open-ended questions to capture their perceptions of CSFs. All reasonable efforts were taken to ensure the reliability and validity of the questionnaire items.

Respondents

Software project managers from Organization Alpha and Organization Bravo responded to an online questionnaire. Both Alpha and Bravo develop and maintain software for the Air Force. Both operate at Level 3 on the Software Development-Capability Maturity Model. They have documented, standardized, and defined their work processes in management and software engineering so that results are repeatable and can be analyzed to some basic extent. Alpha has approximately 565 civilians, 178 officers, and 678 enlisted. Bravo has approximately 546 civilians, 29 officers, and 28 enlisted. Most software project managers and program managers are civilians and officers, while most of the code programmers and technology experts are enlisted and civilians.

Commanders of both organizations endorsed the invitation to take this questionnaire and emailed the invitation to all of their software program managers and project managers (Appendix A). The questionnaire was available online from December 15th to January 20th. The commanders sent reminders on January 13th. Stanton (1998) indicates measurement equivalence between internet questionnaires and traditional paper versions. A copy of the questionnaire is in

Appendix B. The questionnaire refers to software in general because the project managers dealt with a variety of software products, each with different levels of complexity and source lines of code.

Description of the Questionnaire

The research literature on CSFs has used two methodologies: the case study and the questionnaire. The case study commonly involves the researcher visiting one organization, interviewing the project managers, and drawing conclusions on that one organization. This study used the questionnaire method to study multiple organizations, elicit information on specific subjects, and infer conclusions on multiple organizations.

The questionnaire addressed the three investigative questions by asking about the relevant constructs: 1) success criteria and goals, 2) user interaction and satisfaction, and 3) CSFs. Because each construct required a methodologically different set of items, the questionnaire was divided into four parts: the first part for demographic data and the other parts for each construct.

To answer the first investigative question, an ipsative questionnaire asked respondents to prioritize project success criteria. The questionnaire repeatedly asked the respondents to show preference for one of two success criteria under different software projects and with different combinations of criteria. Ideas for the different software projects categories came from examples described in Alpha's and Bravo's websites. These items were Part II of the questionnaire.

For each software project, the respondents selected one of the success criteria twice, the second criteria once, and the third criteria not at all. The success criteria selected twice is the respondent's greatest preference, and the one selected not at all is the lowest preference. These results formed a matrix of priorities for each software system and showed the level of preference

for each success criteria. The questionnaire used 5 different projects and had 3 items per project mixed in the 15 items. An example item asked, "While developing a new personnel system, which is more important? on budget or meeting expectations."

The second investigative question was addressed by having respondents answer Slevin and Pinto's (1986) questionnaire for the following CSFs on user interaction: client consultation, client acceptance, and communication. In Slevin and Pinto's questionnaire, user interaction consists of the project manager's efforts to consult with the client on the project's progress, secure the client's acceptance of this progress, and maintain open communication with the client. The respondents also answered Pinto and Slevin's (1988) questionnaire on project success, which was designed to evaluate the success of a project from the project manager's perceptions. The items addressing this investigative question are in Part III of the questionnaire. The items for this part of the questionnaire were answered with 11-point Likert scales. For example, here is an item for project success: "This project has/will come in on schedule. Strongly Disagree 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 Strongly Agree. 5 is Neutral."

And for the third investigative question, the respondents selected the 10 factors they considered most critical for project success from a list of 23 taken from literature on project management (White & Fortune, 2002). Items addressing this question are in Part IV of the questionnaire.

Development and Validation of the Questionnaire

Numerous steps were taken to ensure the reliability and validity of the questionnaire. Appropriate and valid instruments were derived from peer-reviewed literature to address each construct. These instruments and methodologies were reviewed in other literature for improvements and critiques. The questionnaire was reviewed in a pilot test and pretest by

students and professors in software engineering and information resource management. The research in progress was briefed in an academic conference for feedback. Professors and the research sponsor helped ensure the questionnaire's wording was understandable to the intended audience. And after the questionnaire was conducted, the data provided strong reliability scores and factor loading.

1. Derived instruments from literature: Each part of the questionnaire used a different instrument methodology to properly address the different constructs.
    a. Tamir and Lunetta's (1977) research indicates the ipsative method (also known as paired comparison) is an appropriate way to survey preferences. Relevant items were made under this methodology.
    b. Slevin and Pinto (1986) and Pinto and Slevin (1988) provide validated items for the constructs of user interaction and project success. These Likert scale items were useful in learning the degree each respondent supported user interaction and the extent of his/her project's success. Pinto and Slevin also developed standards to gauge whether a project was successful, approaching success, or unsuccessful. These standards were based on their study of 418 projects (Slevin & Pinto, 1988).
    c. White and Fortune (2002) describe their questionnaire in detail, one part of which dealt with CSFs. To best compile CSF examples, respondents had to have a choice over what they selected, a list to expedite their search for words to describe these CSFs, and a blank box so they could add in any perceived CSFs not on the list. White and Fortune's items were also useful because they provided raw data to compare results with, their research was recent, and their list of potential CSFs

was consistent with the rest of the questionnaire by including the CSFs found by Slevin and Pinto (1986).

2. Reviewed literature's validation of instruments:
    a. Tamir and Lunetta's (1977) research indicates ipsative procedures with approximately 20 items have satisfactory internal consistency coefficients.
    b. Slevin and Pinto (1986) designed and validated their diagnostic survey instrument with psychometric properties to assign scores to the CSFs of a project. The instrument has 5 items for each of the 10 CSFs. Slevin and Pinto conducted a corrected item-total correlation to find good questions that strongly correlated with the results from the other questions. This technique provided internal consistency for the scale items. When Slevin and Pinto surveyed 85 project managers, the questionnaire yielded a Cronbach alpha coefficient averaging 0.86. Pinto and Slevin (1988) added a section to their diagnostic instrument to measure a project manager's perception of a project's success. They validated the questionnaire on CSFs and project success based off of a study of 418 projects.
    c. The Likert scales for items on client consultation, client acceptance, communication, and feedback are 11-point scales. Hinkin (1998) notes coefficient alpha reliability for Likert scales increase up to five points, but do not gain much more value with more points. The 11-point scales helped provide variance among answers.
    d. White and Fortune (2002) derived the 23 factor list from an exhaustive review of CSF project management literature. They also include a 24th blank factor so respondents can provide additional factors they consider critical to success.

3. Read critiques of the questionnaires: Slevin and Pinto (1986), Pinto and Slevin (1988), and Pinto and Prescott (1988) tested their questionnaire every time they published new research on CSFs and project success. Belout (1998) also critiqued the questionnaire. Overall, the items were found to be valid and reliable for the study on project management.

    a. Pinto and Prescott (1988) tested the reliability and validity of the ten CSFs by analyzing answers from 408 project manager respondents who took the questionnaire. Just as before (Slevin & Pinto, 1986), the Cronbach alpha scores for the internal consistency of the CSFs were high, ranging from 0.79 to 0.90. Pinto and Prescott conducted a confirmatory factor analysis for each of the CSFs, which indicated construct validity for every factor. "The factor loadings ranged from 0.49 to 0.90 with the average being 0.64" (Pinto & Prescott, 1988, p. 11).

    b. In 1990, Pinto and Mantel use the CSF questionnaire again, this time to study project failure in R&D and construction. They hypothesized that if CSFs lead to project success, then their absence should lead toward project failure. Pinto and Mantel surveyed 130 people, mostly from the Project Management Institute, a professional association of project managers. 97 people responded, which yielded a 75% response rate. T-tests showed no bias on research variables for early and late respondents.

    c. Pinto and Mantel (1990) tested the CSF construct again for internal consistency, and they once again derived Cronbach alpha scores ranging from 0.79 to 0.90. They conducted a confirmatory factor analysis on the dependent variables of project failure/success to determine whether "[they] were, in fact, a valid

subdimensional representation of the elements of perceived success or failure of a project" (Pinto & Mantel, 1990, p. 272). The failure/success construct did emerge and accounted for 66.9% of total variance in project failure.

d. Pinto and Mantel (1990) used stepwise regression to analyze how strongly each absent CSF impacted different projects at different stages under different failure criteria. Their results confirm earlier work: the CSFs were definitely critical in avoiding project failure. Thus, CSFs for success and their absence for failure strongly correlate and indicate convergent validity.

e. Belout (1998) argues that Pinto and Slevin do not rigorously define the dependent variable "project success" nor precisely measure it. He considers Pinto and Slevin's literature review of project success to be a limited validation of the measure. "This is very critical since a debate exists about the complexity of this construct [project success]" (Belout, 1998, p. 12).

f. There were no critiques available for White and Fortune's study (2002) because it was recently published.

4. Pilot test: To improve this survey, a pilot test was conducted to identify any poorly worded items and practice analyzing data to make sure it revealed the useful information. Twelve respondents from the Air Force Institute of Technology (AFIT) critiqued the pilot test: seven software engineering graduate students enrolled in an advanced software engineering class and five software engineering professors. This group had representative characteristics of the population for this study because of their educational and occupational background. They had an average of 6.4 years of software project management experience. They recommended standardizing the questionnaire's

terminology with words and meanings that software engineers and project managers commonly use and have a common understanding.

5. Pre-test: One professor and ten graduate students in AFIT's information resource management program tested the online version of the questionnaire to critique the formatting, spelling, and wording, and to ensure the questionnaire detected improper answers, recorded all answers, and was user friendly. For example, the respondents recommended putting a point of contact on the questionnaire in case respondents had questions. They also recommended offering an executive summary of the research results to respondents. This would act as an incentive for anyone curious about the research and they would see that their input was used.
6. Briefed at conference: This research was briefed for peer review during an academic conference. Ten business and project management professors critiqued the methodology and literature review.
7. Reviewed with software project manager and used standardized terminology:
    a. A software project manager consultant in Organization Alpha reviewed multiple versions of the questionnaire and recommended improvements in terminology so it would make sense to the prospective respondents. While her suggestions changed some wording and added clarifications, the content of the questionnaire remained true to the literature it was derived from. For example, where Slevin and Pinto (1986) refer to "clients" who are paying for the project, the questionnaire now refers to "customers" to fit with the terminology in the Systems Engineering Process List of Definitions (Anon, 2002). This list of definitions and the consultant's proofreading helped clarify the distinctions between similar

words and ensure the correct interpretation of each item's intended meaning. For example, while a "customer" is the person or organization paying for the software product, "users" are the people who will use the software product in their daily work.

b. Terminology was also taken from an online software professional development curriculum that was designed for software project managers at Alpha, Bravo, and any other Air Force software developing units. For example, the questionnaire asks the software project managers what phase of the software lifecycle their project is currently going through. Because literature offers a number of software lifecycle models (like the Waterfall Model, the Sawtooth Model, and the Spiral Model), examples of life cycle phases came from the software professional development curriculum. This ensured the respondents had a common frame of reference for software project management concepts.

c. The researcher also visited the headquarters of Organization Alpha to brief prospective respondents on the general problem background of the research and elicit their feedback.

8. Checked reliability and factor analysis: The Likert scale items in Part III of the questionnaire was appropriate for factor analysis. The items referring to user consultation, user commitment, communication, and project success were analyzed with factor analysis. The set of items for each construct loaded strongly on one component. Within a rotated component matrix, most items loaded above 0.8 in the varimax rotation method. Under Cronbach reliability analysis, all sets of items had at least a Cronbach

alpha of 0.8015 up to 0.9566. A Cronbach alpha of at least 0.70 indicates satisfactory reliability (Nunnally, 1976).

Methodology for Data Analysis

For the first investigative question, the data was analyzed by simply taking the statistical mean of all respondents' preferences. This provided the preferences of software project managers in prioritizing success criteria by showing how each criterion was prioritized first on average. This observation indicated software project managers' priorities for meeting requirements, schedules, and budgets. For example, if 50 project managers prioritized between budget and schedule, and 45 of them prioritized budget first, then the budget became a higher priority on average. This indication becomes more accurate as the project managers repeatedly must make priority decisions throughout this part of the questionnaire.

For the second investigative question, Pinto and Slevin's (1988) questionnaire was designed to convert data on user interaction and project success into scores to measure the success of the project under user satisfaction and the traditional success criteria (requirements, budget, and schedule). By studying 418 projects, Pinto and Slevin developed standardized scores of project success that classified a project's status as good (above the 80th percentile of the success scores the 418 project achieved), fair (between the 50th and 80th percentile), and critical (below the 50th percentile). A good project was successful in practically all ways (on time, on budget, fulfills requirements, and satisfies user). A fair project fulfilled some or most criteria for success. And a critical project failed most to achieve most criteria and required serious attention to fix. Client consultation, client acceptance, and communication are considered independent variables because Pinto and Mantel (1990) had already tested and found a cause-and-effect relationship between the 10 CSFs and the dependent variables, which are

project success and client satisfaction. Multiple regression in this study was used to determine how strongly the independent variables of user interaction correlated to the dependent variable of project success

And for the third investigative question, the nonparametric data was examined with Kendall's and Spearman's Rank Correlation methods. Each respondent selected 10 CSFs out of a list of 23 possible. A rank ordering of CSFs was derived from adding up how many times each CSF was selected. Kendall's and Spearman's Rank Correlation methods were used to detect any statistically significant differences between the rank orders of this study's results and White and Fortune's (2002). These methods use a null hypothesis and an alternate hypothesis in a two-tailed test:

H_n: $r = 0$.

H_a: $r \neq 0$.

Spearman's rank correlation coefficient, r (Spearman's rho), indicates how well the two rank orderings correlate. A perfect positive correlation would be $r = 1$. A perfect negative correlation would be $r = -1$. As the coefficient of r approaches 0, the correlation decreases to the point of 0, in which there is absolutely no correlation.

Kendall's method is intended for a smaller number of responses (fewer than 10). Kendall's method thus works well for deeper analysis of the data for demographic groupings within the larger respondent population of 64 (e.g.: there were 9 project managers in charge of projects developed by contractors).

By contrasting the results of this study with White and Fortune's results, this study identified differences between Air Force software project managers perceived CSFs and the

private sector. Comparisons were also made between cross sections of the data for demographic groupings.

By comparing data within demographic groupings, this study sought to infer more than the cumulative average. These demographic groupings break respondents up by service (military and civil service), project role (project manager and program manager), veteran experience in software engineering and/or project management ($10 > x \geq 5$ years and $x \geq 15$ years), type of project (sustaining a legacy system and developing a new product), primary developer (government, commercial off the shelf, and contractor), and the project's status (good and critical).

The military service members include both enlistees and officers. Although enlistees usually have responsibilities different from officers, the two enlisted respondents classified themselves as software project managers, rather than as project leads, project team members, or other. Therefore, the enlistees probably had the same duties and software project management knowledge as the officer respondents.

White and Fortune (2002) include past experience as one of the CSFs that other researchers had identified. Therefore, project manager experience was used as a discriminator to see how it affected the other variables. 5 years is the baseline because the Project Management Institute requires a person (among other criteria) to have at least 3 years of experience managing a project to apply for the association's certification as a project manager. As such, 5 years was a conservative baseline to expect project managers to make good decisions in project management through lessons learned from experience. The 5 to 10 year group of respondents is contrasted with the 15+ year respondents to look for any conspicuous differences between the two that might not be visible by also including the 10 to 15 year group.

Summary

This exploratory study sought to examine many different topics, each which required a different questionnaire and methodology that was best suited to it (Table 4). This study collected reliable and valid data to analyze and learn about Air Force software project management.

Table 4
Summary of Methodology

	Investigative Question	Questionnaire Measures	Analysis Methodology
1	How do Air Force software project managers prioritize the three traditional measures of project success?	15 items, ipsative (Tamir & Lunetta, 1977)	Statistical Means
2	Does high user interaction in Air Force software projects correlate with project success?	27 items, 11-point Likert scales (Pinto & Slevin, 1988; Slevin & Pinto, 1986)	Multiple Regression
3	Are the critical success factors for Air Force software projects different from private sector projects?	23 items, open-ended (White & Fortune, 2002)	Spearman's Rank Correlation

IV. Data Analysis

Overview

The respondents provided a variety of data for the questionnaires. A straightforward look at the data indicates answers to this exploratory study's investigative questions on goals, user interaction and project success, and CSFs. However, even more can be inferred by examining the data through cross sections of the respondents.

Demographics

The questionnaire invitation was sent to 214 people whom Organization Alpha and Organization Bravo classified as software project managers. There were 71 respondents, which yielded a 33.2% response rate. Six respondents only answered half the questionnaire, and they are consequently not included in the data analysis for the second and third investigative questions. Likewise, one respondent invalidated his answers by stating he was not knowledgeable enough to properly answer the questions. Raw data on demographics is available in Appendix C.

The majority of the respondents were civil servants (Table 5), with an average of 24.5 years of time in government service and 12 years of experience with project management and/or software engineering. Approximately half of the respondents were project managers (in charge of one project) and the other half were program managers (in charge of multiple projects) (Table 6).

Table 5

Respondent Demographics, by Pay Grade

Service Category and Pay Grade	Number of Respondents	Years Working for AF	Experience with Project Management and/or Software Engineering (Years)
GS-10 to GS-14	55	24.5	12
O-4 to O-6	1	6	3
O-1 to O-3	11	7.7	1.5
E-7 to E-9	2	21	6
Other	1	28	22

Table 6

Respondent Demographics, by Project Role

#	Role	#	Service Category and Pay Grade	Years Working For AF	Years of Experience in Project Management and/or Software Engineering
28	program manager	21	GS-10 to GS-14	21.5	11.8
		6	O-1 to O-3	10.8	2
		1	other	28	22
24	project manager	16	GS-10 to GS-14	27.1	14.1
		1	O-4 to O-6	6	3
		5	O-1 to O-3	4	0.8
		2	E-7 to E-9	21	6
9	project lead	9	GS-10 to GS-14	23.1	14.3
3	project team member	3	GS-10 to GS-14	25.7	9.3
6	other	6	GS-10 to GS-14	29.3	5.3

First Investigative Question

1. How do Air Force software project managers prioritize the three traditional measures of project success?

Respondents prioritized "meeting expectations" first 56.6% of the time, distantly followed by "on time" (24.2%) and "on budget" (19.2%) (Appendix D). Table 7 shows how other cross sections of the respondents prioritized their goals.

Table 7
Goals by Cross Section

		Selected % of the Responses		
Cross Section		Time	Budget	Meeting Expectations
Average of All Respondents		24.2	19.2	56.6
Project Status	Good	23.9	22.1	53.9
	Critical	22.5	19.7	57.8
Experience Software Engineering and/or Project Management	≥ 15 Years	26.7	15.2	58.1
	10 > x ≥ 5 Years	20.0	18.7	61.3
Project Type	Sustaining	25.3	19.4	55.2
	New Developing	20.0	22.0	58.0
Service	Military	23.8	26.7	49.5
	Civil Service	24.6	17.1	58.3
Developer	GOTS	26.2	18.7	55.1
	COTS	15.2	28.6	56.2
	Contractor	20.7	15.6	63.7
Role	Project Manager	27.2	17.8	55.0
	Program Manager	27.2	17.8	55.0

Note. Military service respondents included officers and enlistees.

Table 7 shows that most of the cross sections closely follow the average of all respondents. The military members are slightly different with a higher concern for budgets, and COTS project managers are the most concerned about the budget and least concerned about the schedule out of all the respondents, and the project managers for contracted projects are the most concerned about meeting expectations and the least concerned about finishing on budget.

Second Investigative Question

2. Does high user interaction in Air Force software projects correlate with project success?

Multiple regression analysis of the data indicates an adjusted *r* square of 0.735, which suggests the CSFs for user interaction account for a large part of project success. The multiple regression model was also statistically significant ($p < 0.05$). Most of the 64 surveyed projects were sustaining a legacy system (35) versus a new start software development effort (17), and most projects were government developed (41) rather than based off of a contracted project (9) or commercial off the shelf software (7) (Appendix E). The respondents provided a diversity of projects for analysis, rather than solely claiming all projects had high levels of success. 22 were good (successful), 18 were fair (approaching success), and 24 were critical (unsuccessful) (Appendices F and G). Appendix H shows on average that items were answered in the positive half of the Likert scale, but the standard deviations reveal there was a wide range of responses to some of the items.

The project managers with 5 to 10 years of experience had the highest percentage of failed projects for their experience group (69% were critical) and the fewest successful projects (15% were good). This is surprising because this group actually had a lower perception of their project success than the group with less than 5 years of experience (42% were critical and 26% were good). The group of project managers with 15+ years of experience had the highest success rate (53% were good) and the lowest rate of failure (16% were critical).

Third Investigative Question

3. Are the critical success factors for Air Force software projects different from private sector projects?

The rank comparison between the research results and White and Fortune's data (2002) using Kendall's tau correlation and the Spearman rank order correlation revealed a positive correlation between the pair of rank orderings (Table 8). The model was statistically significant. However, Spearman's correlation coefficient of 0.547 indicates the correlation is not perfect and that the surveyed project managers had other CSFs than the private sector. The public and private sector agreed on the top seven CSFs, but not in the same order (Table 9).

Table 8

Rank Comparison between Research Results and White and Fortune (2002)

Method	Correlation Coefficient
Kendall's tau-b	0.436
Spearman's rho	0.547

Note. $p < 0.05$

The sharp difference in lower ranked factors is most notable in the CSFs ranked 6, 8.5 (had a tie), and 11 by the Air Force software project managers. The private sector project managers correspondingly ranked them 20, 21.5, and 23. The percent of project managers selecting each CSF emphasized the distinct difference in choice between private and public sector respondents. For example, for the CSF of "support from stakeholders and champions," 53.1% of Air Force project managers selected it, while only 1.3% of private sector project managers selected it. Table 9 displays a complete list of rankings between this study's results and the results of White and Fortune (2002).

Respondents offered four more CSFs that they recommended adding to the list of 23 (Appendix I).

Table 9

Rank Comparison Between CSFs, Research Results and White and Fortune (2002)

CSFs	Rank		% of Respondents Who Selected this CSF	
	Research Results	White & Fortune, 2002	Research Results	White & Fortune, 2002
Adequate funds/resources	1	4	93.8	69.5
Clear goals/objectives	2	1	87.5	87.3
Realistic schedule	3	2	85.9	78.4
End user commitment	4	5	79.7	67.4
Clear communication channels	5	6	71.9	61.0
Having access to innovative/talented people	6	20	64.1	3.4
Support from senior management	7	3	54.7	74.6
Effective management of risk	8.5	13.5	53.1	49.6
Support from stakeholder(s)/champion(s)	8.5	21.5	53.1	1.3
Effective leadership/conflict resolution	10	7	50.0	58.5
Having a clear project boundary	11	23	40.6	0.8
Effective team building/motivation	13.5	13.5	34.4	49.6
Flexible approach to change	13.5	9	34.4	56.4
Having relevant past experience	13.5	21.5	34.4	1.3
Recognizing complexity	13.5	10.5	34.4	51.3
Effective monitoring and feedback	16	8	29.7	57.2
Training provision	17	15	25.0	41.5
Taking account of past experience	18	10.5	18.8	51.3
Taking account of external influences	19	12	15.6	50.8
Considering multiple views of project	20.5	19	9.4	19.9
Provision of planning and control systems	20.5	17	9.4	37.3
Contextual awareness	22	16	7.8	39.8
Appreciating the effect of human error	23	18	6.3	22.5

The demographic groups had very similar rankings to the average (Table 10). The groups that were compared with each other strongly agreed on the ranking. Surprisingly, the Good Projects and Critical Projects had a very high Spearman's rho of 0.91. This indicates the software project managers for both successful and unsuccessful projects agree on CSFs, but the successful project managers are better at applying those CSFs. Likewise, the newer project managers (5 up to 10 years of experience) and more experienced ones (15+ years) strongly agreed on CSFs (0.94) but the newer project managers still had a much higher failure rate.

Table 10
Rank Correlation Among Groups

Compared Rankings		Spearman's rho	Kendall's tau-b
Research	White & Fortune, 2002	0.55	0.44
5 ≤ x < 10 Years	15 ≤ x Years	0.94	0.82
Good Project	Critical Project	0.91	0.77
Project Manager	Program Manager	0.86	0.72
Military	Civil Service	0.84	0.70
Sustainment	New Development	0.81	0.61
GOTS	COTS	0.85	0.70
GOTS	Contractor Developed	0.86	0.70
COTS	Contractor Developed	0.66	0.54

Note. GOTS stands for government developed. COTS stands for commercial off the shelf. $p < 0.05$

Despite the strong agreement in ordering of CSFs, there were still conspicuous differences between demographic groups that could be studied with further research. A full comparison of CSFs between demographic groups is in Appendices J, K, L, M, N, and O.

For example, in comparison with GOTS and COTS (Table 11), far fewer respondents for contracted software projects valued effective management of risk (33%), support from senior management (44%), and training provisions (0%). Perhaps the project managers for contracted projects consider risk management and training provisions to be the responsibility of the contracted company, and senior management is already committed to the projects because of contracts. On the other hand, in comparison with GOTS and contracted projects, far fewer COTS respondents valued having a clear project boundary (0%), recognizing complexity (14%), and having relevant past experience (14%). The COTS project managers may have this view because commercial off the shelf products are by their very nature supposed to be simpler than a product that must be developed from the ground up and the project boundary should be clear cut. Strong documentation in COTS projects may also lessen the necessity of past experience with similar products.

Table 11
CSF Comparison Between GOTS, COTS, and Contractors

	Rank			% of Respondents		
CSFs	GOTS	COTS	Contractor	GOTS	COTS	Contractor
Effective management of risk	7.5	7.5	13.5	56	71	33
Support from senior management	7.5	4.5	10.5	56	85	44
Having a clear project boundary	11	22	8	39	0	56
Recognizing complexity	12.5	16.5	13.5	37	14	33
Having relevant past experience	16	16.5	5.5	29	14	67
Training provision	17	11	22	24	43	0

Note. CSFs are ordered for GOTS.

There were also some distinct differences between project managers and program managers (Table 12). The most noteworthy difference was in having relevant past experience. While 39% of project managers valued it as a top CSF, only 8% of the program managers valued it.

Table 12
CSF Comparison Between Project Managers and Program Managers

	Rank		% of Respondents		Raw Data, # of Respondents Selecting this CSF	
CSFs	Project	Program	Project	Program	Project	Program
Recognizing complexity	10.5	14	48	27	11	7
Support from senior management	10.5	5.5	48	69	11	18
Effective monitoring and feedback	13	18.5	39	15	9	4
Having relevant past experience	13	20.5	39	8	9	2
Training provision	13	16	39	23	9	6
Considering multiple views of project	19	20.5	17	8	4	2
Taking account of external influences	20.5	16	9	23	2	6
Provision of planning and control systems	22.5	18.5	4	15	1	4

Note. Highlighted numbers are the top 10 CSFs for each column. Bold-faced numbers have conspicuous differences. CSFs are ordered for project managers.

Three times as many military members are concerned about external influences than civil service employees, who, in turn, are three times as concerned about building an effective team (Table 13).

Table 13
CSF Comparison Between Military and Civil Service

CSFs	Rank		% of Respondents		Raw Data, # of Respondents Selecting this CSF	
	Military	Civil Service	Military	Civil Service	Military	Civil Service
Recognizing complexity	8.5	16	50%	31%	7	14
Support from stakeholder(s)/ champion(s)	11.5	7	43%	60%	6	27
Training provision	11.5	17	43%	22%	6	10
Taking account of past experience	14	18	36%	16%	5	7
Taking account of external influences	15.5	20.5	29%	11%	4	5
Having a clear project boundary	17.5	11	21%	49%	3	22
Having relevant past experience	17.5	13	21%	42%	3	19
Effective team building/motivation	19.5	12	14%	44%	2	20
Provision of planning and control systems	23	19	0%	13%	0	6

Note. Highlighted numbers are the top 10 CSFs for each column. Bold-faced numbers have conspicuous differences. CSFs are ordered for military members.

Differences also materialized between project managers responsible for sustaining a legacy system (software maintenance) and project managers developing new software (Table 14). 29% of the new start respondents valued taking account of past experience and taking account of external influences, while 11% of the respondents for sustainment valued past experience and only 3% accounted for external influences as a CSF.

Table 14
CSF Comparison Between Sustaining A Legacy System and New Start Software Development

	Rank		% of Respondents		Raw Data, # of Respondents Selecting this CSF	
CSFs	Sustain	New Start	Sustain	New Start	Sustain	New Start
Effective management of risk	7	10.5	63	41	22	7
Having a clear project boundary	9.5	19.5	49	18	17	3
Effective leadership/conflict resolution	11	5.5	46	65	16	11
Effective team building/motivation	12	17.5	43	24	15	4
Having relevant past experience	13	17.5	40	24	14	4
Taking account of past experience	18	14	11	29	4	5
Taking account of external influences	22	14	3	29	1	5
Appreciating the effect of human error	23	19.5	0	18	0	3

Note. CSFs are ordered for sustaining a legacy system.

As noted earlier, the project managers with 5 to 10 years of experience had the highest percentage of failed projects out of all the 5 year groups, while the project managers with 15 and more years of experience had the highest percentage of successful projects. Surprisingly, a comparison between these two groups reveals a very strong similarity in the percentage of respondents choosing CSFs (Table 15). The differences between these two groups appear to be insignificant. The one CSF they differ on is training provisions, with 32% of respondents of 15+ years choosing it, and only 8% of project managers with 5 up to 10 years of experience choosing it.

This strong agreement in CSFs possibly indicates both groups of project managers have had the same project management and software engineering education during the last five years. In which case, the 15+ year group could be making wiser use of the CSFs in contrast to the less experienced group.

Table 15
CSF Comparison Between Project Managers with 5 to 10 and 15+ Years of Experience

	Rank		% of Respondents		Raw Data, # of Respondents Selecting this CSF	
CSFs	5 ≤ yrs < 10	15+ yrs	5 ≤ yrs < 10	15+ yrs	5 ≤ yrs < 10	15+ yrs
Clear goals/objectives	1.5	2.5	100	84	13	16
End user commitment	1.5	4.5	100	74	13	14
Realistic schedule	3	2.5	92	84	12	16
Adequate funds/resources	4	1	85	100	11	19
Having access to innovative/talented people	5	4.5	77	74	10	14
Clear communication channels	7	6	62	68	8	13
Effective leadership/conflict resolution	7	7.5	62	58	8	11
Support from stakeholder(s)/champion(s)	7	9	62	53	8	10
Support from senior management	9	7.5	54	58	7	11
Effective management of risk	10	14.5	46	37	6	7
Training provision	22	16.5	8	32	1	6

Note. CSFs are ordered for project managers with 5 up to 10 years of experience.

Similar to the different groups of experience, the project managers of successful projects and critical projects have a very close percentage of respondents selecting the same CSFs (Table 16). Although these project managers agreed on CSFs, perhaps the successful project managers approached these CSFs differently than the unsuccessful project managers. The fact CSFs do not seem to correlate with project success may also indicate CSFs have no relation to project success.

One distinct difference exists in building an effective team, which 55% of the successful respondents chose versus only 25% of the critical respondents. The successful respondents, on the other hand, considered support from senior management to be less important (36%), while 67% of the critical respondents chose it as a CSF.

Table 16
CSF Comparison Between Successful and Critical Projects

	Rank		% of Respondents		Raw Data, # of Respondents Selecting this CSF	
CSFs	Success	Critical	Success	Critical	Success	Critical
Adequate funds/resources	1	3	100	88	22	21
Clear goals/objectives	2	3	86	88	19	21
Realistic schedule	3	1	82	92	18	22
Clear communication channels	4	5	77	75	17	18
Having access to innovative/talented people	5	6	73	71	16	17
End user commitment	6	3	68	88	15	21
Effective leadership/conflict resolution	7	9	59	58	13	14
Effective management of risk	8.5	10	55	46	12	11
Effective team building/motivation	8.5	15	55	25	12	6
Support from stakeholder(s)/champion(s)	11	7.5	41	67	9	16
Support from senior management	13.5	7.5	36	67	8	16

Note. CSFs are ordered for successful projects.

Limitations

Stanton and Rogelberg (2001) reviewed literature on the pros and cons of online questionnaires. Applicable risks to such research include access control, authentication, multiple responding, and an uncontrolled response environment. The online questionnaire for this study was not linked to any other website, thereby impeding random web surfers from answering the questionnaire. To maintain anonymity, the respondents did not have to authenticate themselves. Authentication was not a concern because all respondents worked in software project organizations, regardless of whether they were the original recipients of my emails. Therefore, their answers were still useful.

Stanton and Rogelberg (2001) advise how to minimize the possibility of someone responding multiple times: 1) avoid angering the respondents, 2) request one response per respondent, and 3) confirm their answers before submitting to the database. The questionnaire and invitation were designed to implement their recommendations. The uncontrolled response environment (the respondent's situation and office when answering the items) was not within the study's control, and Stanton and Rogelberg concedes that "this offers no worse a challenge than standard mail-return survey practices" (p. 210).

Stanton and Rogelberg (2001) also note the danger that some parts of the respondent population may not have access to online questionnaires, which would bias the results toward those people who do have access.

This was not a pressing issue for this study because, in general, all people working on software project management have to have computer access. Furthermore, Simsek and Veiga (2001) note "[Online questionnaires] can prove quite beneficial for obtaining opinions related to new software. Likewise, because most large firms [like the Air Force] and their managerial/professional employees have access to e-mail, sample surveys for these populations

are possible" (p. 97). Simsek and Veiga, therefore, expect software project managers would likely have email and internet access.

The section of the questionnaire eliciting CSFs had a limitation because it may not include all true critical success factors for software project management.. To minimize this limitation, respondents had the option to add in CSFs which were not on the questionnaire list but that the respondents thought should be included.

Archival data was unavailable to cross-check the extent to which the respondents followed through on how they prioritized their goals.

The data analysis could be more refined for each software organization if the questionnaire had asked respondents to designate which organization they worked for. Although Organization A and B used similar training curriculum and terminology, it is possible they assign different responsibilities to their software project managers.

Bias in the results may exist because some invitation recipients did not respond to the questionnaire. The nonrespondents may have had different perceptions than those who did respond.

Summary

The respondents provided a great deal of data to use in answering the three investigative questions. Although the questions can be answered by averaging out the data, an analysis within each demographic group provided an even more refined view of the data and distinctions between the groups. The analysis also revealed surprising similarities, such as between successful and critical projects. Limitations in the research acknowledge this study is imperfect. Nonetheless, inferences can be made from this data thanks to the many steps taken to make it valid and reliable.

V. Conclusion

Interpreting the Data and Drawing Conclusions

This exploratory study began with the following three investigative questions:

1. How do Air Force software project managers prioritize the three traditional measures of project success?
2. Does high user interaction in Air Force software projects correlate with project success?
3. Are the critical success factors for Air Force software projects different from private sector projects?

The questionnaire results indicate private sector research on these constructs is mostly generalizable to the two surveyed Air Force units, specifically Organization Alpha and Organization Bravo. Although researchers have found public sector differences in the procedures, contracting, and documentation of software acquisitions, project management itself is not much different from the private sector for these two organizations. Therefore, many of the private sector advances in project management should be applicable to these Air Force organizations, as well.

With the first investigative question, the data indicates software project managers in these two organizations prefer to fulfill requirements over budget and schedule concerns. This is interesting because it does not line up well with cost as an independent variable (CAIV) for major automated information systems, despite directives that have provided guidance for CAIV since 1996. Possibly, software project managers realize they can always deliver a project on time and on budget without fulfilling requirements, but the product would perform poorly and not gain customer satisfaction. Nonetheless, cost is still an important issue, especially because cost overruns can provoke the cancellation of poorly done projects. Therefore, project managers

should reorient the traditional success criteria toward satisfying all three with trade-offs. For example, a project manager and customer team could prioritize 40 requirements for a software project. As money and time run out, the project manager could disregard the lowest priority requirements in favor of finishing the project on time, on budget, and fulfilling those requirements that are most important to the customer.

With the second investigative question, highly successful Air Force projects had strong user interaction, and unsuccessful projects did not. Private sector research has recommended user interaction for at least the last 10 years. However, this measure is apparently not a rule of thumb in Organization Alpha and Organization Bravo, judging from the 24 critical projects and some fair projects that lacked user interaction. But the strong adjusted *r* square of 0.735 and low *P* value indicate this is a compelling model that shows the importance of strong user interaction for a successful project. Every large project with a separation between the project manager and end-users should have at least a liaison to represent the end-users and the customers paying for the project.

The third investigative question had an answer that suggests a partial difference between the private sector and the two Air Force organizations. Although the Air Force software project managers and private sector project managers shared many of the same CSFs, there were still some distinct differences. These differences probably come from the different organizational cultures and environments. For example, Air Force project managers may have highly valued "having access to innovative/talented people" because these people are a scarce resource in the Air Force. Many innovative/talented people periodically move to another assignment to progress in their careers or leave the military to work elsewhere. On the other hand, private sector managers have the freedom to hire innovative/talented people for competitive salaries and then

just as easily fire them when the economy goes into a recession. So, Air Force project managers must value the people they have, while private sector managers may consider them to be a dime a dozen.

There were also some disparities between groupings of the data. While most groupings agreed on most CSFs, they occasionally had distinct differences. The successful and unsuccessful project managers were most remarkable of all, though. Both strongly agreed on CSFs, yet the CSFs did not seem to have any predictive value in achieving project success. Possibly both groups of software project managers had the same training that told them these CSFs were important, but only the successful project managers were good at using these CSFs. Or it could be that the CSF construct is invalid and has very little bearing on the success of a project for these two organizations. If this is so, then CSFs are just mythical silver bullets that are supposed to ensure project success, and the real answer could be all the processes involved with producing software, as per the various capability maturity models.

Research Implications

For the practitioner, these results provide information to make better decisions. For example, the necessity to balance the trade-offs of not reaching all goals but still producing a software product that both the customer and user will accept and be satisfied with. Good user interaction throughout the life cycle can strengthen user satisfaction. Consequently, the two Air Force organizations may desire to make user interaction into mandatory policy. And this research revealed which CSFs are valued most by the software project managers of Alpha and Bravo. With these CSFs in mind, software project managers for these organizations can allocate their attention appropriately to these factors as they progress toward a successful project.

For academics, this research explored a topic that has many precedents in the private sector and no precedents in the public sector, specifically software development and maintenance within Alpha and Bravo. This study can be a founding stone for future research that explores differences in the CSFs. Future research could also quantify the relationships between CSFs and project success and test the causative nature of the correlations that this study found. It could also test the legitimacy of CSFs.

Further Research

There are several opportunities for further research. Different research methodologies and questions would provide more insight into the cost overruns and other failure issues.

While this questionnaire focused on project managers, a study surveying the project team members could further test generalizability. White and Leifer (1986) surveyed software project team members in the private sector, whereas other researchers focus solely on project managers. Their results indicate project team members consider neither user participation nor senior management support (another CSF) to be vital for a project's success. White and Leifer's study on project team members is one of few focusing on project team members, and thus it invites further study to support their surprising results.

A case study on the new Air Force personnel information system, MILPDS (formerly known as MilMod), could yield useful data to aid the Army's new information software system. Literature on project management and software development has consistently identified failed information systems and software projects as a common problem for the last 30 years. Although corporations and the government have made many information systems and researchers have studied the art of successful software project management, there are still no rules to guarantee project success. Public sector information systems pose unique difficulties because they deal

with many more employees than a large business and they can cost much more money. The military must learn from MilMod and the new Air Force civilian system to ensure the Army's new information system does not repeat their mistakes.

The comparisons between demographic groups may also lead to new discoveries. In particular, the lack of differences between the successful and unsuccessful projects questions the legitimacy of the CSF construct for Air Force software project management. Or perhaps moderators are influencing the impact that CSFs are supposed to make in promoting project success.

Appendix A, Questionnaire Invitation

Dear [Alpha/Bravo] member,

The Air Force is researching software project success, and we would appreciate your help with this.

Software project success has been a notoriously elusive goal for the private sector. Many projects have either finished over time and over budget or were just canceled. Some finished projects still do not meet specifications or satisfy the customer. For these reasons, researchers have published many studies on this subject in the private sector.

The Air Force is also researching project success. We hope to learn about the different factors that go into the success of software projects and how project managers handle some of these factors.

Both [Alpha] and [Bravo] have volunteered to survey their experts on this topic. You are an expert on software project management because of your insight and insider's knowledge of how it is done in the Air Force. Even members new to software project management have a unique understanding and background that contributes to this study. Although some of our projects may not be completely managed and developed in house, [Alpha] and [Bravo] members still see how the project is working out.

Therefore, I would appreciate your help by answering questions on software project success. Your thoughts would shed some light on this puzzling topic. All answers will be anonymous.

For your convenience, the survey is online:

http://en.afit.edu/env/spm/

Feel free to email me at [student@afit.edu] if you would like to hear about the research results or if you have any questions. I am a graduate student at the Air Force Institute of Technology. My advisor is [professor], [professor@afit.edu].

Both the Air Force Personnel Center and the Union have approved this survey.

Respectfully,

[first name, last name, rank, service]
[office symbol]
[student@afit.edu]

Appendix B, Questionnaire

Survey on Software Project Management

Thank you for taking this survey. Your candid answers will help research on successful project management. All answers will be anonymous.

Credit for designing some of this survey goes to Dr. Jeffrey Pinto and Dr. D.K. Slevin (part III) and to Dr. Diana White and Dr. Joyce Fortune (part IV).

Part I: Background and Perspective

1. Rank:

   --select one--

   - E-1 to E-4
   - E-5 to E-6
   - E-7 to E-9
   - O-1 to O-3
   - O-4 to O-6
   - GS-1 to GS-5
   - GS-6 to GS-9
   - GS-10 to GS-14
   - contractor
   - other

2. How many years have you worked for the Air Force?
(less than 1 year = 0)

3. How many years of experience do you have with software engineering and/or project management? (less than 1 year = 0)

4. What role do you fill with your current or most recent software project?

   --select one---
   - program manager
   - project manager
   - project lead
   - project team member
   - consultant
   - other _____

Any comments or questions?_____

Part II: Project Priorities

With each question, imagine you are in charge of a particular software project, which could deal with personnel, munitions, accounting, mapping, or communications. The three traditional goals of projects managers are to finish on time, on budget, and meet expectations. But sometimes, not all three of these can be met.

With each question, prioritize your goals by selecting your top priority. Even if you have no experience with a particular project, imagine how you would make your decisions. For the ease of answering this survey, only two goals need to be considered for each question. You will see the same questions and responses several times. Do not let previous responses sway your choices.

All of these projects are primarily developed by the government or contractors (i.e. no commercial off the shelf software). For the purposes of this survey, designing, developing, and building a project are all examples of creating a new product and delivering it through the lifecycle to implementation.

Goals
Meet expectations: finish a project according to technical specifications
On time: finish a project early or by its original deadline without extensions
On budget: finish a project within the budget without any requested increases

Project Examples
Personnel system: records annual performance reviews
Munitions system: maintains inventory of munitions
Accounting system: helps automate budgeting, tax preparation, and other financial work
Base map system: displays maps of the base, terrain, streets, utilities, and traffic patterns
Wireless communication system: securely connects laptops with base network

1. When developing a wireless communication system, which is more important?

   on budget or meeting expectations

2. When building a personnel system, which is more important?

   meeting expectations or on budget

3. When designing a munitions system, which is more important?

   on time or on budget

4. When developing an accounting system, which is more important?

   on budget or on time

5. When building a wireless communication system, which is more important?

on time or on budget

6. While developing a personnel system, which is more important?

on budget or on time

7. While designing a base map system, which is more important?

meeting expectations or on budget

8. When developing an accounting system, which is more important?

meeting expectations or on time

9. When building a base map system, which is more important?

on time or on budget

10. When developing a munitions system, which is more important?

on budget or meeting expectations

11. When designing a wireless communication system, which is more important?

on time or meeting expectations

12. When developing an accounting system, which is more important?

meeting expectations or on budget

13. When building a personnel system, which is more important?

meeting expectations or on time

14. While developing a munitions system, which is more important?

on time or meeting expectations

15. When designing a base map system, which is more important?

meeting expectations or on time

Any comments or questions?_____
_____

Part III: User and Customer Interaction

With this third part of the survey, consider the questions with your current or most recent software project. If you are working on several projects simultaneously, just pick one of your projects for these questions.

General Project Questions

1. How would you categorize your project?

    - new start software development
    - sustaining a legacy system
    - other _____

2. How would you classify it?

    - commercial off the shelf
    - government developed
    - other _____

3. Which phase is your project at in the software lifecycle?

    - requirements gathering
    - design
    - implementation
    - maintenance
    - other _____

Customer Project Questions

With this project in mind, consider the following statements. Using the scale below, rate each statement according to the degree to which you agree with the statement as it concerns your project. A rating of 5 indicates that the statement is neutral and you neither agree nor disagree. A rating above 5 indicates agreement with that statement. A rating below 5 indicates disagreement with the statement.

In answering the following questions, these definitions apply:
Customer: the agency requesting your software
Users: the people who will use your software

Strongly Disagree					Neutral					Strongly Agree
0	1	2	3	4	5	6	7	8	9	10

1. The customers were given the opportunity to provide input early in the project development stage.
   0 1 2 3 4 5 6 7 8 9 10

2. The customers are kept informed of the project's progress.
   0 1 2 3 4 5 6 7 8 9 10

3. The value of the project has been discussed with the customers.
   0 1 2 3 4 5 6 7 8 9 10

4. The limitations of the project have been discussed with the customers (what the project is *not* designed to do).
   0 1 2 3 4 5 6 7 8 9 10

5. The customers were told whether or not their input was assimilated into the project plan.
   0 1 2 3 4 5 6 7 8 9 10

6. There is adequate documentation of the project to permit easy use by users (instructions, etc.).
   0 1 2 3 4 5 6 7 8 9 10

7. Potential users have been contacted about the usefulness of the project.
   0 1 2 3 4 5 6 7 8 9 10

8. An adequate presentation of the project has been developed for customers.
   0 1 2 3 4 5 6 7 8 9 10

Strongly Disagree					Neutral					Strongly Agree
0	1	2	3	4	5	6	7	8	9	10

9. The users know who to contact when problems or questions arise.
   0 1 2 3 4 5 6 7 8 9 10

10. Adequate advanced preparation has been done to determine how best to "sell" the project to users.
   0 1 2 3 4 5 6 7 8 9 10

11. The results (decisions made, information received and needed, etc) of planning meetings are published and distributed to applicable personnel.
   0 1 2 3 4 5 6 7 8 9 10

12. Individuals/groups supplying input have received feedback on the acceptance or rejection of their input.
   0 1 2 3 4 5 6 7 8 9 10

13. When the budget or schedule is revised, the changes *and* the reasons for the changes are communicated to customers.
   0 1 2 3 4 5 6 7 8 9 10

14. The reasons for any changes to existing policies/procedures have been explained to customers.
   0 1 2 3 4 5 6 7 8 9 10

15. All groups affected by the project know how to make problems known to me.
   0 1 2 3 4 5 6 7 8 9 10

16. This project has/will come in on schedule.
   0 1 2 3 4 5 6 7 8 9 10

17. This project has/will come in on budget.
   0 1 2 3 4 5 6 7 8 9 10

18. The project that has been developed works (or, if still being developed, looks as if it will work). 0 1 2 3 4 5 6 7 8 9 10

Strongly Disagree					Neutral					Strongly Agree
0	1	2	3	4	5	6	7	8	9	10

19. The project will be/is used by its intended users.
0 1 2 3 4 5 6 7 8 9 10

20. This project has/will directly benefit the intended users: either through increasing efficiency or employee effectiveness.
0 1 2 3 4 5 6 7 8 9 10

21. Given the problem for which it was developed, this project seems to do the best job of solving that problem--- i.e., it was the best choice among the set of alternatives.
0 1 2 3 4 5 6 7 8 9 10

22. Important customers, directly affected by this project, will make use of it.
0 1 2 3 4 5 6 7 8 9 10

23. I am/was satisfied with the process by which this project is being/was completed.
0 1 2 3 4 5 6 7 8 9 10

24. We are confident that non-technical start-up problems will be minimal, because the project will be readily accepted by its intended users.
0 1 2 3 4 5 6 7 8 9 10

25. Use of this project has/will directly lead to improved or more effective decision making or performance for the users.
0 1 2 3 4 5 6 7 8 9 10

26. This project will have a positive impact on those who make use of it.
0 1 2 3 4 5 6 7 8 9 10

27. The results of this project represent a definite improvement in performance over the way end-users used to perform these activities.
0 1 2 3 4 5 6 7 8 9 10

Any comments or questions?_____
_____

Part IV: Critical Success Factors

Which 10 of these 23 factors do you consider most critical to the success of your project? Which factors are essential to success? Please mark your top 10; no rank ordering is necessary. In the textbox below, feel free to note any other factors that should be added to this list as part of your list of 10.

_____ Adequate funds/resources
_____ Appreciating the effect of human error
_____ Clear communication channels
_____ Clear goals/objectives
_____ Considering multiple views of project
_____ Contextual awareness
_____ Effective leadership/conflict resolution
_____ Effective management of risk
_____ Effective monitoring and feedback
_____ Effective team building/motivation
_____ End user/customer commitment
_____ Flexible approach to change
_____ Having a clear project boundary
_____ Having access to innovative/talented people
_____ Having relevant past experience
_____ Provision of planning and control systems
_____ Realistic schedule
_____ Recognizing complexity
_____ Support from senior management
_____ Support from stakeholder(s)/champion(s)
_____ Taking account of external influences
_____ Taking account of past experience
_____ Training provision

Other factor(s):_____

Any comments or questions?_____
_____

Once again, thank you for your help with this study. If you would like an executive summary of my research results, please email me at [student@afit.edu]

Appendix C, Demographics

Raw Data on Respondents

Respondents #2, 6, 16, 21, 24, and 69 only completed Parts I and II of the questionnaire.

Respondents received ID numbers on first come basis. #1 was the first person to respond.

ID #	Rank	Years Working For AF	Years of Experience in Project Management and/or Software Engineering	Role
1	GS-10 to GS-14	23	14	project lead
2	GS-10 to GS-14	12	5	other
3	GS-10 to GS-14	17	7	project lead
4	GS-10 to GS-14	28	3	project team member
5	GS-10 to GS-14	16	12	program manager
6	GS-10 to GS-14	34	27	project manager
7	GS-10 to GS-14	25	20	project team member
8	GS-10 to GS-14	8	3	program manager
9	GS-10 to GS-14	25	25	project lead
10	GS-10 to GS-14	14	10	project manager
11	GS-10 to GS-14	23	12	other
12	GS-10 to GS-14	36	26	project manager
13	GS-10 to GS-14	16	5	project lead
14	GS-10 to GS-14	24	5	project team member
15	GS-10 to GS-14	29	8	project manager
16	GS-10 to GS-14	36	8	project lead
17	GS-10 to GS-14	36	14	project manager
18	GS-10 to GS-14	30	25	project lead
19	GS-10 to GS-14	22	22	project lead
20	GS-10 to GS-14	20	17	program manager
21	GS-10 to GS-14	24	19	program manager
22	GS-10 to GS-14	21	11	project manager
23	O-1 to O-3	19.5	2	program manager
24	GS-10 to GS-14	32	10	program manager
25	GS-10 to GS-14	27	10	program manager
26	other	28	22	program manager
27	GS-10 to GS-14	40	17	project manager
28	GS-10 to GS-14	29	3	program manager
29	GS-10 to GS-14	24	20	program manager
30	GS-10 to GS-14	35	5	other
31	GS-10 to GS-14	8.5	4	project manager

ID #	Rank	Years Working For AF	Years of Experience in Project Management and/or Software Engineering	Role
32	E-7 to E-9	20	6	project manager
33	GS-10 to GS-14	30	4	project manager
34	O-1 to O-3	0	0	project manager
35	GS-10 to GS-14	26	16	program manager
36	O-1 to O-3	11	2	program manager
37	GS-10 to GS-14	29	10	program manager
38	GS-10 to GS-14	2	10	program manager
39	GS-10 to GS-14	29	10	program manager
40	GS-10 to GS-14	15	14	program manager
41	E-7 to E-9	22	6	project manager
42	GS-10 to GS-14	25	8	program manager
43	GS-10 to GS-14	30	20	project manager
44	O-1 to O-3	15	2	program manager
45	O-1 to O-3	9	0	project manager
46	GS-10 to GS-14	20	18	project manager
47	O-1 to O-3	5	0	program manager
48	GS-10 to GS-14	31	20	project manager
49	O-1 to O-3	3	1	project manager
50	GS-10 to GS-14	23	10	program manager
51	O-1 to O-3	10.5	4	program manager
52	GS-10 to GS-14	39	20	project manager
53	GS-10 to GS-14	27	5	other
54	GS-10 to GS-14	26	6	program manager
55	GS-10 to GS-14	26	20	program manager
56	O-1 to O-3	4	2	program manager
57	O-4 to O-6	6	3	project manager
58	GS-10 to GS-14	42	5	other
59	GS-10 to GS-14	19	15	program manager
60	GS-10 to GS-14	17	8	project manager
61	O-1 to O-3	3	1	project manager
62	GS-10 to GS-14	23	15	program manager
63	O-1 to O-3	5	2	project manager
64	GS-10 to GS-14	25	3	project manager
65	GS-10 to GS-14	23	15	project manager
66	GS-10 to GS-14	22	22	project lead
67	GS-10 to GS-14	15	5	program manager
68	GS-10 to GS-14	14	14	program manager
69	GS-10 to GS-14	37	0	other
70	GS-10 to GS-14	17	1	project lead
	Average:	21.5	10.2	

Appendix D, Goals

Goals in Software Project Management

Raw Data

ID #	Personnel			Munitions			Accounting			Base Map			Wireless		
	T	B	ME	T	B	ME	T	B	ME	T	B	ME	T	B	ME
1		1	2	1		2		1	2		1	2	1		2
2	1		2	1		2	1		2	1		2	1		2
3		1	2		1	2		1	2		1	2		1	2
4		2	1	1	1	1		2	1		2	1		2	1
5		1	2		1	2	1		2		1	2		1	2
6	1		2	1		2	1		2		2	1	1		2
7	1		2	1		2	1		2	1		2	1		2
8	1		2	1		2	1		2		1	2	1		2
9	1		2	1		2	1		2	1		2	1		2
10	1		2	1		2	1		2	1	1	1		1	2
11		1	2		1	2		1	2		1	2		1	2
12		1	2		1	2		1	2		2	1	1	1	1
13		2	1	1		2		1	2		1	2	1		2
14	2		1	1		2	1	2			1	2	1		2
15	1		2	1		2	1		2	1		2	1		2
16	1		2		1	2	1		2	1	2			2	1
17	1		2	1		2	1		2	1		2	1		2
18	1		2	1		2	1		2	1		2	1		2
19	1		2	1		2	1		2	1		2	1		2
20	1		2	1		2	1		2	1		2	1		2
21		2	1	1		2	1		2		1	2		1	2
22	1	2			1	2		1	2		1	2		2	1
23	1		2	1		2	1		2	1		2		1	2
24	1		2	1		2	1		2	1		2	1	2	
25		2	1	1		2		2	1	1	2		1		2
26		1	2	1		2		1	2		2	1		1	2
27	1		2	1		2	1		2	1		2	1		2
28	1		2	1		2	1		2		2	1	1		2
29	1	2		1	2		1	2		2	1		1	2	
30		1	2		1	2		1	2		1	2		1	2
31	1		2	1		2	2	1		1		2	2		1
32	2		1	2		1	1		2	2		1		1	2
33	1		2	1		2	1		2	1		2	1		2
34		1	2	1		2	1		2		1	2	1		2
35		1	2	1		2		1	2		1	2	1		2

Appendix D (continued)

	Personnel			Munitions			Accounting			Base Map			Wireless		
ID #	T	B	ME	T	B	ME	T	B	ME	T	B	ME	T	B	ME
36	1		2	1		2	2		1	1		2	1		2
37	1		2	1		2		2	1	1		2	1	2	
38	1		2	1		2	1		2		1	2	1		2
39	1	1	1	1		2	1		2	1		2	1		2
40		1	2		1	2		1	2		2	1	1		2
41		1	2		1	2		1	2		1	2		1	2
42		2	1	1		2		1	2		1	2		1	2
43	1		2	1		2	1		2	1		2	1		2
44		1	2	1		2		1	2		1	2		1	2
45		1	2		1	2	1		2		1	2		1	2
46		1	2	1		2	1		2		2	1	1		2
47	1		2	1	2			2	1	2	1		1	1	1
48	1	1	1	1		2		1	2		2	1	1		2
49	1	1	1	1		2		2	1	1	2			1	2
50	2		1	1		2	1	1	1	1		2	1		2
51		2	1	1	1	1		2	1		1	2		2	1
52	1		2	1		2	1		2		1	2	1		2
53	1		2	1		2	1		2	1		2	1		2
54		1	2	1		2		2	1		1	2	1		2
55		1	2	1		2	1		2		1	2	1		2
56		1	2	2	1		2	1		1		2	1	1	1
57		2	1	1		2		2	1		1	2	1		2
58	1		2	1		2	1		2	1		2	1		2
59	1		2	1		2	1		2	1	2		1		2
60	1		2	1		2		1	2	1		2	1		2
61	1	2		1	2		1	2		1	2		1	2	
62	1	1	1		1	2		1	2	1	1	1	1	1	1
63	1		2	1		2	2		1	1		2	1		2
64	2		1	2	1		2	1		1		2	1		2
65	2		1	1		2		1	2	2	1		2		1
66	1		2	1		2	1		2	1		2	1		2
67		1	2	1		2		1	2		1	2		1	2
68	1		2		1	2		1	2	1		2	1		2
69		1	2	2		1		1	2	1	2		1		2
70	1		2	1		2	1		2	1		2	1		2
Totals	49	43	118	62	22	126	47	46	117	43	56	111	53	35	122

Appendix E, Project Description

ID #	New Software or Legacy	Developer	Lifecycle Phase
1	sustaining a legacy system	other: contractor developed	maintenance
3	new start software development	government developed	implementation
4	new start software development	commercial off the shelf	implementation
5	new start software development	other: contractor developed	other: development
7	sustaining a legacy system	other: contractor developed	maintenance
8	other: sustainment & modernization	government developed	maintenance
9	new start software development	other: contractor developed	implementation
10	sustaining a legacy system	other: both	maintenance
11	sustaining a legacy system	other: contractor developed	maintenance
12	sustaining a legacy system	government developed	maintenance
13	other: modernizing legacy	other: contractor developed	requirements gathering
14	sustaining a legacy system	government developed	maintenance
15	new start software development	government developed	implementation
17	other	government developed	maintenance
18	other: modernization	other: contractor developed	maintenance
19	sustaining a legacy system	government developed	maintenance
20	new start software development	commercial off the shelf	requirements gathering
22	sustaining a legacy system	government developed	implementation
23	sustaining a legacy system	government developed	maintenance
25	sustaining a legacy system	government developed	maintenance
26	other: new start & modernization	other: COTS/GOTS/developed	other: all of the above
27	sustaining a legacy system	government developed	maintenance
28	sustaining a legacy system	government developed	maintenance
29	sustaining a legacy system	government developed	maintenance
30	sustaining a legacy system	government developed	maintenance
31	sustaining a legacy system	government developed	other: all of the above
32	sustaining a legacy system	government developed	maintenance
33	new start software development	government developed	implementation
34	new start software development	government developed	implementation
35	sustaining a legacy system	government developed	maintenance

Appendix E (continued).

ID #	New Software or Legacy	Developer	Lifecycle Phase
36	other: both	government developed	design
37	other: modernization	government developed	design
38	sustaining a legacy system	government developed	maintenance
39	sustaining a legacy system	government developed	requirements gathering
40	sustaining a legacy system	government developed	maintenance
41	sustaining a legacy system	government developed	maintenance
42	sustaining a legacy system	other	maintenance
43	sustaining a legacy system	government developed	implementation
44	other: sustainment of a fairly new system	government developed	maintenance
45	new start software development	commercial off the shelf	design
46	other: modifying an existing system	other: contractor developed	maintenance
47	other: helpdesk management	other: both	other: all
48	sustaining a legacy system	government developed	maintenance
49	new start software development	commercial off the shelf	maintenance
50	sustaining a legacy system	government developed	maintenance
51	new start software development	government developed	design
52	sustaining a legacy system	government developed	maintenance
53	sustaining a legacy system	government developed	maintenance
54	sustaining a legacy system	government developed	maintenance
55	sustaining a legacy system	government developed	maintenance
56	new start software development	government developed	implementation
57	new start software development	commercial off the shelf	design
58	sustaining a legacy system	government developed	maintenance
59	new start software development	other: contractor developed	requirements gathering
60	new start software development	other: both	requirements gathering
61	sustaining a legacy system	government developed	implementation
62	sustaining a legacy system	government developed	maintenance
63	other: transitioning to sustainment	other: both	other: sustain/ req's
64	sustaining a legacy system	government developed	maintenance
65	sustaining a legacy system	government developed	maintenance
66	sustaining a legacy system	government developed	maintenance
67	new start software development	commercial off the shelf	design
68	new start software development	commercial off the shelf	requirements gathering
70	other: eBiz initiative	other: both	implementation

Appendix F, Project Success Scores

	User Interaction CSF Items															Project Success Items												
	Client Consultation					Client Acceptance					Communication					Project Score					Client Score								
ID #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	Total Score
1	9	9	7	6	9	9	5	9	9	5	7	5	8	8	9	5	5	9	9	9	9	9	9	9	9	9	7	98
3	8	10	10	8	8	3	8	6	8	6	8	7	7	6	6	2	2	9	10	10	5	7	7	4	9	9	9	83
4	10	10	10	10	8	10	10	10	10	10	10	10	10	10	10	8	9	10	10	10	10	10	10	10	10	10	10	117
5	10	10	10	10	10	9	10	8	10	8	10	9	10	9	10	8	9	10	10	10	8	10	10	10	10	10	10	115
7	8	8	8	6	7	8	8	8	9	8	9	8	10	9	9	5	8	8	10	10	10	10	10	9	9	9	9	107
8	10	10	10	10	10	6	7	8	9	7	10	9	10	10	6	6	6	9	10	9	9	9	8	9	9	9	10	103
9	10	10	10	10	10	10	10	10	10	10	10	10	10	5	9	9	9	10	10	10	10	10	9	10	10	10	10	117
10	8	9	8	7	7	8	8	8	9	7	8	7	9	8	8	4	4	8	9	9	8	9	7	6	8	8	8	88
11	7	8	7	7	8	6	6	8	10	7	7	6	4	4	4	6	4	8	8	8	9	8	6	6	6	7	8	84
12	10	9	9	9	8	10	10	10	8	10	7	7	9	8	9	8	8	9	9	9	9	9	9	9	9	8	8	104
13	5	5	8	4	4	4	7	5	7	5	5	8	7	7	6	5	5	5	7	7	5	6	6	6	7	7	7	73
14	2	6	3	9	5	8	8	9	10	9	7	4	8	9	9	10	10	10	10	8	9	9	10	9	8	7	8	108
15	2	5	5	5	8	9	7	9	10	7	5	8	8	8	9	2	5	10	10	10	10	10	10	3	10	10	10	100
17	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	120
18	9	9	9	9	9	8	9	8	8	8	9	9	9	2	8	9	8	9	9	9	9	9	8	9	9	9	9	106
19	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	120
20	10	10	8	10	10	9	9	10	10	7	10	8	10	10	10	8	8	10	10	10	10	10	10	9	10	10	10	115
22	10	10	10	10	10	8	10	10	10	10	10	10	10	10	10	10	10	10	8	8	8	8	10	8	10	10	10	110
23	9	8	10	9	10	10	1	10	10	5	10	10	10	5	9	8	3	10	10	10	5	9	10	8	9	10	10	102
25	10	8	10	10	8	3	10	9	10	3	5	5	6	6	10	7	7	10	10	10	10	10	10	10	10	10	10	114
26	10	10	10	7	10	8	10	10	10	7	10	8	10	8	10	6	6	9	10	10	10	10	6	6	10	10	10	103
27	8	10	10	8	8	9	7	6	10	7	10	10	10	10	10	9	9	10	10	10	8	9	9	10	9	9	10	112
28	10	10	10	10	10	7	10	9	10	8	7	10	10	10	10	8	2	7	10	6	8	9	7	8	8	8	8	89
29	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	120
30	7	7	7	5	5	4	5	4	9	7	8	6	7	7	8	7	7	7	7	7	7	7	7	7	7	7	7	84
31	10	10	10	10	10	8	7	10	10	5	10	10	10	10	8	8	8	9	10	10	10	10	4	9	9	9	7	103
32	5	8	8	8	8	7	5	8	9	5	9	9	9	9	9	7	7	9	7	8	8	8	6	5	8	8	9	90
33	10	8	8	8	8	8	8	8	8	8	8	8	8	8	8	5	8	8	8	8	8	8	8	8	8	8	8	93
34	6	10	10	7	6	8	10	8	9	7	9	8	9	9	8	10	10	10	10	9	4	6	9	7	8	6	7	96
35	10	10	10	10	10	10	7	7	10	7	7	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	120
36	10	10	10	8	8	8	8	7	10	9	8	8	8	8	8	9	5	9	8	10	9	9	9	9	9	9	10	105

Appendix F (continued).

	User Interaction CSF Items															Project Success Items												
	Client Consultation					Client Acceptance					Communication					Project Score					Client Score								
ID #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	Total Score
37	10	10	10	10	10	10	10	10	10	8	10	10	10	10	10	7	8	8	10	9	9	8	8	9	9	9	9	103
38	8	8	10	8	9	7	9	8	9	7	6	6	8	8	8	6	7	7	8	8	8	8	6	7	7	8	8	88
39	10	10	10	9	9	9	9	9	10	8	9	9	10	10	10	10	10	10	10	10	10	10	9	9	10	10	10	118
40	10	10	10	10	10	8	10	10	10	10	10	10	10	10	10	3	8	10	10	10	9	10	8	9	9	9	10	105
41	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	120
42	8	8	7	6	7	6	7	7	8	7	7	7	7	6	6	6	6	7	8	7	7	7	7	7	7	8	7	84
43	9	8	8	8	8	8	8	6	10	8	8	8	8	8	10	2	5	10	10	10	10	9	2	8	9	10	9	94
44	10	10	10	10	10	7	10	9	10	8	9	9	10	10	8	9	9	10	10	10	10	10	10	8	10	10	10	116
45	2	2	5	2	3	1	2	4	6	4	3	4	3	5	6	5	6	5	5	5	3	5	3	5	5	5	5	57
46	10	9	9	9	9	10	10	9	10	10	10	10	8	9	9	8	9	10	10	10	10	10	10	10	10	10	10	117
47	10	9	10	9	9	9	8	9	10	9	9	9	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	120
48	4	9	9	7	5	3	5	9	10	9	9	5	3	3	10	10	10	9	9	7	9	9	10	8	8	8	8	105
49	7	8	8	5	6	6	7	7	10	9	10	8	8	7	10	7	6	7	7	8	7	7	7	8	8	8	7	87
50	8	9	10	10	9	9	10	10	10	9	9	9	8	9	10	3	6	9	9	10	9	10	9	9	10	10	10	104
51	10	10	10	10	10	9	6	10	10	2	9	7	10	10	9	10	10	10	8	10	9	9	6	8	10	10	10	110
52	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	8	8	10	10	10	10	10	10	10	10	10	10	116
53	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	120
54	9	9	9	5	6	5	6	5	7	7	8	5	5	5	7	10	10	5	5	5	8	8	8	7	7	7	7	87
55	6	5	6	5	7	7	6	8	9	8	6	8	9	9	7	9	9	9	9	8	7	7	6	6	7	7	7	91
56	7	5	6	6	6	8	6	7	6	6	6	7	7	6	5	6	2	2	6	6	5	6	4	4	5	4	6	56
57	10	8	10	10	10	10	10	10	10	9	7	5	5	5	5	9	0	7	10	10	10	10	8	5	10	10	10	99
58	9	9	5	7	9	5	5	5	9	4	6	8	5	5	9	6	6	8	8	7	9	9	1	9	9	9	9	90
59	10	9	9	7	10	9	5	9	10	7	9	9	9	9	9	9	8	8	8	8	10	10	10	8	8	8	8	103
60	8	10	10	9	10	5	7	6	7	4	6	8	8	8	8	7	7	7	8	8	9	7	7	8	8	8	5	89
61	4	4	4	4	4	10	4	4	5	1	1	2	0	4	8	0	0	10	10	10	9	9	0	5	10	10	10	83
62	10	10	10	10	9	9	3	9	9	3	9	8	10	10	9	9	9	9	9	10	10	10	9	9	9	9	10	112
63	10	10	7	7	10	6	5	7	9	0	3	1	7	7	8	9	9	9	4	3	3	2	9	4	3	6	7	68
64	10	10	10	10	10	10	8	8	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	120
65	7	7	7	7	7	7	7	7	9	8	7	7	7	7	8	7	7	7	7	7	7	7	7	7	7	7	7	84
66	10	10	10	10	10	10	10	10	10	5	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	120
67	10	9	9	9	8	9	9	9	9	9	9	9	9	9	7	8	9	10	9	9	8	8	7	5	7	8	8	96
68	5	5	6	5	5	5	10	6	7	6	5	9	5	5	5	5	5	5	10	5	5	5	5	5	5	5	5	65
70	10	10	10	9	9	10	9	5	9	9	5	9	9	9	5	7	7	7	10	9	10	10	10	10	10	9	10	109

Appendix G, Pinto and Slevin's Project Scores

	Percentile Score	Raw Score					
Status	% of Individuals Scoring Lower	Consultation	Acceptance	Communication	Project	Client	Total
Good	100	49	50	50	50	70	120
	90	46	45	45	49	66	115
	80	42	43	41	46	63	109
Fair	70	40	41	38	44	60	104
	60	38	39	36	43	59	102
	50	35	37	35	41	56	97
	40	32	35	33	40	54	94
Critical	30	30	33	32	37	50	87
/ Failed	20	27	30	28	34	47	81
	10	20	26	25	31	44	75
	0	9	7	6	7	19	26

Note. Combination of information from Slevin and Pinto (1986) and Pinto and Slevin (1988). Pinto and Slevin reduced questionnaire from 10 items to 5 items per construct. Parts of questionnaire had 7-point Likert scales (1988) and other parts had 11-point Likert scales (1986). Converted all items to 11-point Likert scale.

Appendix H, Mean Responses and Range to User Interaction and Project Success

Subject	Item	Range	Min	Max	Mean	Std. Dev	Variance	N
User Consultation	1	8	2	10	8.5	2.2	4.9	64
	2	8	2	10	8.7	1.8	3.3	64
	3	7	3	10	8.7	1.8	3.2	64
	4	8	2	10	8.2	2.0	4.0	64
	5	7	3	10	8.4	1.9	3.5	64
User Acceptance	6	9	1	10	7.8	2.2	4.8	64
	7	9	1	10	7.8	2.2	5.0	64
	8	6	4	10	8.2	1.8	3.2	64
	9	5	5	10	9.2	1.2	1.4	64
	10	10	0	10	7.3	2.4	5.6	64
Communication	11	9	1	10	8.1	2.1	4.3	64
	12	9	1	10	8.0	2.1	4.3	64
	13	10	0	10	8.3	2.1	4.6	64
	14	8	2	10	8.1	2.1	4.4	64
	15	6	4	10	8.5	1.6	2.7	64
Project Success	16	10	0	10	7.4	2.5	6.0	64
	17	10	0	10	7.3	2.6	6.8	64
	18	8	2	10	8.7	1.7	2.8	64
	19	6	4	10	9.0	1.4	2.1	64
	20	7	3	10	8.8	1.6	2.6	64
User Interaction	21	7	3	10	8.5	1.9	3.5	64
Success	22	8	2	10	8.7	1.6	2.6	64
	23	10	0	10	8.0	2.4	5.7	64
	24	7	3	10	8.0	1.9	3.7	64
	25	7	3	10	8.7	1.6	2.4	64
	26	6	4	10	8.7	1.5	2.2	64
	27	5	5	10	8.8	1.5	2.2	64
Cumulative (raw data)								
Consulting	1 to 5	36	14	50	42.5	8.7	75.6	64
Acceptance	5 to 10	33	17	50	40.4	7.5	55.8	64
Communication	10 to 15	35	15	50	41.0	8.3	68.6	64
Procect Score	15 to 20	28	22	50	41.2	6.9	48.2	64
Client Score	20 to 27	39	31	70	59.3	10.1	102.4	64
Total Score		64	56	120	100.5	16.2	261.0	64

Note. Pinto and Slevin's (1988) items on Project Success asked about achievement of the traditional success criteria of finishing on budget, on time, and fulfilling all requirements.

Appendix I, CSF Selection, Overall

Raw Data from this Study and White & Fortune, 2002

CSFs	White & Fortune, 2002	Research Results*
Adequate funds/resources	164	60
Appreciating the effect of human error	53	4
Clear communication channels	144	46
Clear goals/objectives	206	56
Considering multiple views of project	47	6
Contextual awareness	94	5
Effective leadership/conflict resolution	138	32
Effective management of risk	117	34
Effective monitoring and feedback	135	19
Effective team building/motivation	117	22
End user commitment	159	51
Flexible approach to change	133	22
Having a clear project boundary	2	26
Having access to innovative/talented people	8	41
Having relevant past experience	3	22
Provision of planning and control systems	88	6
Realistic schedule	185	55
Recognizing complexity	121	22
Support from senior management	176	35
Support from stakeholder(s)/champion(s)	3	34
Taking account of external influences	120	10
Taking account of past experience	121	12
Training provision	98	16

*Four respondents added 1 CSF each to the list as part of their total selection of 10 CSFs.

Verbatim
End user/customer involvement/participation, and clearly understanding and effectively communicating your program scope issues, and status, and understanding each stakeholder's perspective
Integrated well led team with access to engineering and systems analysis expertise
Taking advantage of but not being driven by technology
Adequate validation of incrementally delivered products

Appendix J, CSF Comparison Between GOTS, COTS, and Contractor-Developed Projects

CSFs	Rank			% of Respondents			Raw Data, # of Respondents Selecting this CSF		
	GOTS	COTS	Contractor	GOTS	COTS	Contractor	GOTS	COTS	Contractor
Adequate funds/resources	1.5	1.5	1.5	95.1	100.0	100.0	39	7	9
Clear goals/objectives	1.5	7.5	4	95.1	71.4	77.8	39	5	7
Realistic schedule	3	1.5	1.5	85.4	100.0	100.0	35	7	9
End user commitment	4	4.5	3	78.0	85.7	88.9	32	6	8
Clear communication channels	5	4.5	5.5	70.7	85.7	66.7	29	6	6
Having access to innovative/talented people	6	9.5	8	68.3	57.1	55.6	28	4	5
Effective management of risk	7.5	7.5	13.5	**56.1**	**71.4**	**33.3**	23	5	3
Support from senior management	7.5	4.5	10.5	**56.1**	**85.7**	**44.4**	23	6	4
Support from stakeholder(s)/champion(s)	9	9.5	10.5	51.2	57.1	44.4	21	4	4
Effective leadership/conflict resolution	10	4.5	8	43.9	85.7	55.6	18	6	5
Having a clear project boundary	11	22	8	**39.0**	**0.0**	**55.6**	16	0	5
Effective team building/motivation	12.5	12.5	17.5	36.6	28.6	22.2	15	2	2
Recognizing complexity	12.5	16.5	13.5	**36.6**	**14.3**	**33.3**	15	1	3
Flexible approach to change	14	12.5	13.5	34.1	28.6	33.3	14	2	3
Effective monitoring and feedback	15	16.5	13.5	31.7	14.3	33.3	13	1	3
Having relevant past experience	16	16.5	5.5	**29.3**	**14.3**	**66.7**	12	1	6
Training provision	17	11	22	**24.4**	**42.8**	**0.0**	10	3	0
Taking account of past experience	18	16.5	17.5	17.0	14.3	22.2	7	1	2
Provision of planning and control systems	19.5	16.5	22	12.2	14.3	0.0	5	1	0
Taking account of external influences	19.5	16.5	17.5	12.2	14.3	22.2	5	1	2
Contextual awareness	21	16.5	22	9.7	14.3	0.0	4	1	0
Considering multiple views of project	22	22	20	7.3	0.0	11.1	3	0	1
Appreciating the effect of human error	23	22	17.5	4.9	0.0	22.2	2	0	2

Note. Highlighted numbers are the top 10 CSFs for each column. Bold-faced numbers have conspicuous differences. CSFs are ordered for GOTS.

Appendix K, CSF Comparison Between Project Managers and Program Managers

CSFs	Rank		% of Respondents		Raw Data, # of Respondents Selecting this CSF	
	Project	Program	Project	Program	Project	Program
Adequate funds/resources	1	2	91.3	92.3	21	24
Clear goals/objectives	2.5	3	82.6	88.5	19	23
End user commitment	2.5	5.5	82.6	69.2	19	18
Realistic schedule	4	1	78.3	96.0	18	25
Clear communication channels	5	5.5	73.9	69.2	17	18
Effective management of risk	6	8	56.5	61.5	13	16
Effective leadership/conflict resolution	8	11.5	52.2	42.3	12	11
Having access to innovative/talented people	8	5.5	52.2	69.2	12	18
Support from stakeholder(s)/champion(s)	8	9	52.2	53.8	12	14
Recognizing complexity	10.5	14	**47.8**	**26.9**	11	7
Support from senior management	10.5	5.5	**47.8**	**69.2**	11	18
Effective monitoring and feedback	13	18.5	**39.1**	**15.4**	9	4
Having relevant past experience	13	20.5	**39.1**	**7.7**	9	2
Training provision	13	16	**39.1**	**23.1**	9	6
Having a clear project boundary	15	11.5	34.8	42.3	8	11
Effective team building/motivation	16.5	11.5	30.4	42.3	7	11
Flexible approach to change	16.5	11.5	30.4	42.3	7	11
Taking account of past experience	18	16	21.7	23.1	5	6
Considering multiple views of project	19	20.5	**17.4**	**7.7**	4	2
Appreciating the effect of human error	20.5	22.5	8.7	3.8	2	1
Taking account of external influences	20.5	16	**8.7**	**23.1**	2	6
Contextual awareness	22.5	22.5	4.3	3.8	1	1
Provision of planning and control systems	22.5	18.5	**4.3**	**15.4**	1	4

Note. Highlighted numbers are the top 10 CSFs for each column. Bold-faced numbers have conspicuous differences. CSFs are ordered for project managers.

Appendix L, CSF Comparison Between Project Managers and Program Managers

CSFs	Rank		% of Respondents		Raw Data, # of Respondents Selecting this CSF	
	Military	Civil Service	Military	Civil Service	Military	Civil Service
Adequate funds/resources	1	1	100.0	91.8	14	45
Clear goals/objectives	2.5	2	92.8	95.6	13	43
Realistic schedule	2.5	3	92.8	91.1	13	41
End user commitment	4	4	78.6	86.7	11	39
Clear communication channels	5	5	71.4	80.0	10	36
Having access to innovative/talented people	6.5	6	57.1	71.1	8	32
Support from senior management	6.5	9	57.1	57.8	8	26
Effective management of risk	8.5	9	50.0	57.8	7	26
Recognizing complexity	8.5	16	**50.0**	**31.1**	7	14
Effective leadership/conflict resolution	11.5	9	42.9	57.8	6	26
Flexible approach to change	11.5	14	42.9	35.6	6	16
Support from stakeholder(s)/champion(s)	11.5	7	**42.9**	**60.0**	6	27
Training provision	11.5	17	**42.9**	**22.2**	6	10
Taking account of past experience	14	18	**35.7**	**15.6**	5	7
Effective monitoring and feedback	15.5	15	28.6	33.3	4	15
Taking account of external influences	15.5	20.5	**28.6**	**11.1**	4	5
Having a clear project boundary	17.5	11	**21.4**	**48.9**	3	22
Having relevant past experience	17.5	13	**21.4**	**42.2**	3	19
Contextual awareness	19.5	22.5	14.3	6.7	2	3
Effective team building/motivation	19.5	12	**14.3**	**44.4**	2	20
Appreciating the effect of human error	21.5	22.5	7.1	6.7	1	3
Considering multiple views of project	21.5	20.5	7.1	11.1	1	5
Provision of planning and control systems	23	19	**0.0**	**13.3**	0	6

Note. Highlighted numbers are the top 10 CSFs for each column. Bold-faced numbers have conspicuous differences. CSFs are ordered for military members.

Appendix M, CSF Comparison Between Software Sustainment and Development

CSFs	Rank		% of Respondents		Raw Data, # of Respondents Selecting this CSF	
	Sustain	New Start	Sustain	New Start	Sustain	New Start
Clear goals/objectives	1	4	94.3	76.5	33	13
Adequate funds/resources	2	2	91.4	94.1	32	16
Realistic schedule	3	2	88.6	94.1	31	16
Clear communication channels	4	7.5	80.0	58.8	28	10
End user commitment	5.5	2	71.4	94.1	25	16
Having access to innovative/talented people	5.5	7.5	71.4	58.8	25	10
Effective management of risk	7	10.5	**62.9**	**41.2**	22	7
Support from senior management	8	5.5	57.1	64.7	20	11
Having a clear project boundary	9.5	19.5	**48.6**	**17.6**	17	3
Support from stakeholder(s)/champion(s)	9.5	9	48.6	47.1	17	8
Effective leadership/conflict resolution	11	5.5	**45.7**	**64.7**	16	11
Effective team building/motivation	12	17.5	**42.9**	**23.5**	15	4
Having relevant past experience	13	17.5	**40.0**	**23.5**	14	4
Recognizing complexity	14	14	34.3	29.4	12	5
Effective monitoring and feedback	15	14	31.4	29.4	11	5
Flexible approach to change	16	10.5	28.6	41.2	10	7
Training provision	17	14	20.0	29.4	7	5
Taking account of past experience	18	14	**11.4**	**29.4**	4	5
Considering multiple views of project	20	21	8.6	11.8	3	2
Contextual awareness	20	22.5	8.6	5.9	3	1
Provision of planning and control systems	20	22.5	8.6	5.9	3	1
Taking account of external influences	22	14	**2.9**	**29.4**	1	5
Appreciating the effect of human error	23	19.5	**0.0**	**17.6**	0	3

Note. Highlighted numbers are the top 10 CSFs for each column. Bold-faced numbers have conspicuous differences. CSFs are ordered for sustaining a legacy system.

Appendix N, CSF Comparison Between Project Managers with 5 to 10 Years and 15+ Years of Experience

CSFs	Rank 5 ≤ yrs < 10	Rank 15+ yrs	% of Respondents 5 ≤ yrs < 10	% of Respondents 15+ yrs	Raw Data, # of Respondents Selecting this CSF 5 ≤ yrs < 10	Raw Data, # of Respondents Selecting this CSF 15+ yrs
Clear goals/objectives	1.5	2.5	**100.0**	**84.2**	13	16
End user commitment	1.5	4.5	**100.0**	**73.7**	13	14
Realistic schedule	3	2.5	**92.3**	**84.2**	12	16
Adequate funds/resources	4	1	**84.6**	**100.0**	11	19
Having access to innovative/talented people	5	4.5	**76.9**	**73.7**	10	14
Clear communication channels	7	6	**61.5**	**68.4**	8	13
Effective leadership/conflict resolution	7	7.5	**61.5**	**57.9**	8	11
Support from stakeholder(s)/champion(s)	7	9	**61.5**	**52.6**	8	10
Support from senior management	9	7.5	**53.8**	**57.9**	7	11
Effective management of risk	10	14.5	**46.2**	**36.8**	6	7
Having relevant past experience	11	11.5	38.5	42.1	5	8
Having a clear project boundary	12.5	11.5	30.8	42.1	4	8
Recognizing complexity	12.5	14.5	30.8	36.8	4	7
Effective monitoring and feedback	15	11.5	23.1	42.1	3	8
Effective team building/motivation	15	11.5	23.1	42.1	3	8
Flexible approach to change	15	16.5	23.1	31.6	3	6
Appreciating the effect of human error	18.5	21.5	15.4	5.3	2	1
Contextual awareness	18.5	21.5	15.4	5.3	2	1
Provision of planning and control systems	18.5	18.5	15.4	10.5	2	2
Taking account of past experience	18.5	18.5	15.4	10.5	2	2
Considering multiple views of project	22	21.5	7.7	5.3	1	1
Taking account of external influences	22	21.5	7.7	5.3	1	1
Training provision	22	16.5	**7.7**	**31.6**	1	6

Note. Highlighted numbers are the top 10 CSFs for each column. Bold-faced numbers have conspicuous differences. CSFs are ordered for project managers with 5 up to 10 years of experience.

Appendix O, CSF Comparison Between Successful Projects and Critical Projects

CSFs	Rank		% of Respondents		Raw Data, # of Respondents Selecting this CSF	
	Success	Critical	Success	Critical	Success	Critical
Adequate funds/resources	1	3	**100.0**	**87.5**	22	21
Clear goals/objectives	2	3	**86.4**	**87.5**	19	21
Realistic schedule	3	1	**81.8**	**91.7**	18	22
Clear communication channels	4	5	**77.3**	**75.0**	17	18
Having access to innovative/talented people	5	6	**72.7**	**70.8**	16	17
End user commitment	6	3	**68.2**	**87.5**	15	21
Effective leadership/conflict resolution	7	9	**59.1**	**58.3**	13	14
Effective management of risk	8.5	10	**54.5**	**45.8**	12	11
Effective team building/motivation	8.5	15	**54.5**	**25.0**	12	6
Flexible approach to change	11	13.5	40.9	29.2	9	7
Having a clear project boundary	11	11	40.9	37.5	9	9
Support from stakeholder(s)/champion(s)	11	7.5	**40.9**	**66.7**	9	16
Effective monitoring and feedback	13.5	16.5	36.4	20.8	8	5
Support from senior management	13.5	7.5	**36.4**	**66.7**	8	16
Having relevant past experience	15.5	12	31.8	33.3	7	8
Recognizing complexity	15.5	16.5	31.8	20.8	7	5
Training provision	17	13.5	27.3	29.2	6	7
Taking account of past experience	18	19	18.2	12.5	4	3
Contextual awareness	19	22	13.6	8.3	3	2
Considering multiple views of project	20.5	22	9.1	8.3	2	2
Taking account of external influences	20.5	19	9.1	12.5	2	3
Provision of planning and control systems	22	19	4.5	12.5	1	3
Appreciating the effect of human error	23	22	0.0	8.3	0	2

Note. Highlighted numbers are the top 10 CSFs for each column. Bold-faced numbers have conspicuous differences. CSFs are ordered for project managers with successful projects.

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14. ABSTRACT

Private sector project success depends on many elements. Three of them are user interaction with the project's development, critical success factors, and how the project manager prioritizes the traditional success criteria. High user interaction causes high customer satisfaction, even when the traditional success criteria are not completely met. Critical success factors are those factors a project manager must properly handle to avoid failure. And priorities influence which success criteria the project manager will most likely succeed in meeting. This exploratory study found that Air Force software project management in two surveyed organizations has much in common with research findings in the private sector in comparable software systems. The top priority of the respondents is fulfilling requirements. User interaction during the software life cycle strongly influences user satisfaction with the final product. Air Force and private sector projects share many of the same critical success factors for nonweapon systems, but there are still some sharp differences.

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